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American Tool Making
AND
Interchangeable Manufacturing

American Tool Making
AND
Interchangeable Manufacturing

A Treatise upon the Designing, Constructing, Use, and Installation
of Tools, Jigs, Fixtures, Devices, Special Appliances, Sheet-
Metal Working Processes, Automatic Mechanisms, and
Labor-Saving Contrivances; together with Their Use
in the Lathe, Milling Machine, Turret Lathe,
Screw Machine, Boring Mill, Power Press,
Drill, Sub-Press, Drop Hammer, etc.,
for the Working of Metals, the
Production of Interchangeable
Machine Parts and the
Manufacture of Rep-
etition Articles
of Metal

By

JOSEPH V. WOODWORTH

Author of "Dies, Their Construction and Use," "Hardening, Tempering,
Annealing, and Forging of Steel," etc

*ILLUSTRATED BY SIX HUNDRED ENGRAVINGS
FROM ORIGINAL DRAWINGS BY
THE AUTHOR*

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PREFACE.

By this preface I offer to American tool-makers a treatise on their art—and mine. My reasons for this venture are numerous, but chief among them is the fact that to every tool-maker, every machinist, every worker in metals, a knowledge of what can be attained in his art is to-day indispensable, and the attainment of that knowledge should be both easy and pleasant.

This treatise is intended for the man at the head of the shop as well as the man at the lathe; for the man who has neither the time nor the inclination to delve into ten or twenty volumes of more or less contradictory mechanical dissertation; for the practical man of the drafting-room, the tool-room, the machine-shop, and the forge. The work is dedicated to the work-bench of the mechanic and the office of the engineer. It is inscribed to all who are interested in the working of metals. If they shall gain knowledge by its perusal the author will be abundantly repaid.

In the writing and illustrating of this work I have drawn upon the accumulated knowledge gained through many years of practical experience, and have embodied in it extracts from over three hundred original articles contributed by myself to the mechanical and the technical press. In arranging the text and the illustrations the following objects have been constantly kept in mind:

I. To give accurate and concise descriptions of the fundamental principles, methods, and processes by which the greatest accuracy and highest efficiency may be attained in the production of repetition parts of metal at the minimum of cost.

II. To discuss and illustrate the great numbers of special tools, their construction and use, as fully as possible within the narrow limits of a single volume.

III. To avoid all that is speculative, impracticable, and obsolete in processes, methods, principles, design, and construction.

IV. To preserve a clear and systematic arrangement of the numerous subjects, giving to each one its place according to its importance in the treatise.

V. To secure a style and method of presentation in the work itself which shall please the busy man of metals, whether he labors in the shop, the draughting-room, the office, or the laboratory.

Thus my aim has been to increase the practical knowledge and the earning capacity of machinists, tool-makers, die-makers, steel-workers, blacksmiths, model-makers, and foremen; to point out to superintendents where and how to secure the maximum of output from the minimum of cost and labor; to give general managers and proprietors of metal-working establishments methods by which they may increase the output and the income, and—last, but not least—to put into the hands of the earnest and intelligent apprentice a text-book of the art that has gained for the United States the industrial supremacy of the world.

Whether these important ends have been attained, it is not for me but for the practical reader to decide. I have labored earnestly and assiduously to add to the world's stock of knowledge and to reach the ideal of what a work of this kind should be.

I surrender the treatise, thus undertaken and completed, to the reader, apologizing for nothing contained in it or omitted, and asking of you only a considerate judgment and just recognition of the work.

JOSEPH V. WOODWORTH.

NEW YORK,
December, 1904.

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American Tool Making
AND
Interchangeable Manufacturing

AMERICAN TOOL-MAKING.

CHAPTER I.

The Inception, Development, and Installation of the Modern System of Interchangeable Manufacturing.

ELI WHITNEY.

THE inception of the modern system of interchangeable manufacturing—according to the best authorities—was in 1798; and the honor of being the first "interchangeable manufacturer" belonged to Eli Whitney, the inventor of the cotton-gin, who, in January of that year, secured an order to furnish the United States Government with ten thousand muskets, four thousand to be delivered in one year and the balance in two years. We read that "Mr. Whitney went at the undertaking in a very thorough and systematic way. First, he developed a water-power, erected suitable and adequate buildings, considered ways and means for a larger and better product, designed machinery to effect it, and trained workmen to skill in the new employment. However, the difficulties which he encountered were greater than he had supposed, and it was eight years instead of two before the order of ten thousand arms was completed. Notwithstanding this delay, the progress of the enterprise and the character of the product as delivered was so satisfactory otherwise that Congress treated him with the greatest consideration. His shops at New Haven, Conn., became the Mecca of government officials, manufacturers, travelling notables, and foreigners, and that which he could show was well worth a journey, for his innovations in the manufacture of arms were as epochal as his invention of the cotton-gin." It was in the manufacture of those muskets that Whitney first conceived and put into successful operation "jigs" and "fixtures" for the duplicate production of parts to a limited degree of variation which would permit of their interchanging. Thus the modern manufacturing system was born—the system that not only revolutionized the manufacture of arms, but became the basis upon which American manufacturers built their present-day reputation of superiority in all other lines of manufactures.

Having gone this far—as the origin of the system has been traced and the inventor given due credit, as well as having paid tribute to his genius—it will be well to proceed with the presentation of the meaning of "interchangeability" and the development, perfecting, and installation of the system for which it stands.

INTERCHANGEABILITY.

Interchangeability mechanically means to produce parts in duplication or repetition, or the production of a part or piece which will fit into the place provided for any other similar piece. As a rough sample of interchangeability we might take, for instance, the work of the brick-layer, the tile-setter, or the mosaic-worker, who when building a wall or blocking a panel take any brick, tile, or cube that lies nearest to their work, knowing that it will take up the same amount of space and fit into place the same as those laid before it. In metal, a rough sample of interchangeability is met with when laying a line of water-pipe, the castings being dropped indiscriminately along the street, the contractor knowing full well that one end of each will fit into the recess of the end of the preceding one.

From the laying of bricks, tiles, and water-pipe to the making of watches is quite a long step; but as the modern watch, cheap and expensive, represents the other extreme of interchangeability, developed to a degree almost incomprehensible to the ordinary mind, it is a fitting illustration. In the manufacture of the watch hundreds of parts go to make it up. Take the screws—the tiny little things that one can hardly see with the naked eye; they are manufactured by the million, and so accurately that the last one will fit perfectly into the tapped hole provided for the first one. The gears, springs, brackets, pinions, pivots, bearings, and shafts are all interchangeable.

In referring to interchangeability it must not be inferred that the system is only met with in the production of fine work; on the contrary, the fact is that the system is easier of installation and of as frequent occurrence with rough work.

In modern manufacturing the first object sought is to produce cheaply and therefore rapidly, and this object can only be attained by producing the parts or machines of the same kind in duplication. Some infer that these modern manufacturing methods have been adopted on account of the scarcity of skilled labor, when the fact is that it has been the great supply of highly skilled labor that has made the development, perfection, and installation of the wonderful system of interchangeable manufacturing possible. Thus where years ago the skill and ingenuity of the mechanic were monotonously and patiently utilized in the hand production of a number of parts of great accuracy to a certain attainable degree of duplication, they are now directed to the devising and constructing of one part or tool, or a set of tools, which will produce other parts or tools in endless repetition. In modern machine manufacturing skill and ingenuity of an order higher than were ever thought possible to attain have been developed in the hands and brains of the American tool-maker. And this skill and ingenuity are concentrated upon the devising of means for the production of articles and parts within the slightest possible limits of variation, and in which their complete interchangeability will be guaranteed.

The man in whose brain the modern manufacturing system was born was he that first took a piece of scrap-iron and drilled two holes in it, to guide a drill in making another piece with two holes in it the same distance apart as in the first piece. The men who now fill our drawing-rooms and tool-rooms and who devise and construct tools for the production of interchangeable metal parts are his descendants. They have made possible the manufacture of the breach-loading gun, the typewriter, the cheap sewing-machine, the cash-register, the machine-made watch, the automobile, as well as a thousand and one other mechanical articles, machines, and devices, which form an integral part of our twentieth-century civilization.

INTERCHANGEABLE MANUFACTURING.

The development of the modern system of manufacturing since the days of Eli Whitney has been simply wonderful, so that at the present time all machines for which there is a constant or a large demand are or should be manufactured and built through this system of interchangeability. It is in the perfecting of this system and in the designing and constructing of tools and appliances for the successful production of machinery that the best and brightest men in the mechanical field are employed. Take the universal milling-machine, the precision-lathe, the automatic screw-machine, and turret-lathe; all these machines are being manufactured to-day by a system which allows of their being constructed and shipped to any part of the world with their efficiency guaranteed. Moreover, any one of their innumerable parts can, when worn out or broken, be duplicated by sending to the works and securing the part needed. This part can then be fastened in place of the other without as much as touching it with a file, when it will perform its separate and distinct movements as positively and accurately as the part whose place it has taken.

When one realizes that, in order for these machines to do the work expected from them, each and every part, from the most minute screw to the largest casting, must be finished to a degree of accuracy almost inconceivable to the lay mind, the fact that all the parts *will interchange* with those on another machine becomes more surprising. Now if all the parts of a modern machine tool must be finished so accurately, to what degree must the tools and appliances used to produce them be finished? And what of the men who have the skill and mental capacity necessary for the successful designing and constructing of such tools!

If it is considered that twenty years ago precision-machine tools of the present efficiency could not have been constructed, not even if the best mechanics available were employed on the work, the fact that they, as well as numberless others, are now, and have been, built by thousands, becomes more astonishing.

The reason why such machinery could not have been perfected and constructed to accomplish the results now attained by them was that there were not at that time tools and machines of the necessary precision and accuracy to build them, and it was only by inventing and developing the use of such tools that the manufacture of such intricate pieces of mechanism as the modern universal miller, precision-lathe, etc., was made possible. Naturally, in order to develop and construct these tools, the minds and hands of the mechanics had to be developed, until to-day the amount of brains, skill, and mental capacity involved in the designing and constructing of special machinery, dies, tools, and fixtures for the manufacturing of metal parts, articles, appliances, and machinery, is equal to—if not greater than—that called into use in any of the other arts and professions.

This may seem a rather strong assertion to make, but it is made with the full knowledge of what it means. It may not be apparent to all, but to the man who has had the advantage of practical observation and experience in the manufacturing of machinery it is both right and just. It is well that the fact is becoming universally recognized that men of the highest and rarest attainments are engaged in the devising and developing of means for the rapid and economic production of machinery.

MODERN MANUFACTURING OF INTRICATE MACHINERY.

As a practical illustration of what the modern system of manufacturing consists and how it is installed and carried on, I will take up the various arts called into use and necessary to the successful constructing and placing on the market of a machine for which there is a large demand.

After the developing and experimenting has reached a successful conclusion in a perfect working model, the first thing necessary is the designing and making of full sets of wood and metal patterns, to be used for casting the various parts which are to be cast. The man that does this must call into play a vast amount of ability and knowledge in order to accomplish this part of the work. He must allow of all parts being sufficiently strong, so that the castings resulting will withstand all strain to which they may be subjected when in use, and he must provide for giving them, as far as possible, a symmetrical and artistic appearance. He must also allow for shrinkage in the metal when cast and for a certain amount of surplus stock at all points which are to be machined and finished.

After the pattern-maker has produced these patterns in exact duplication of the designs, they are sent to the foundry, where the moulder utilizes his skill and brains, and, with the patterns as models, a heap of sand and a few crude tools to work with, works out his moulds, from which a set of castings are produced. This set is first machined and finished by the use of the best means available, which calls into use all the capacity and skill of the machinist. After all parts have been finished and assembled, a finished machine is the result. Any defects in shape or strength in the patterns have now become apparent in the finished castings and the parts. The patterns are then carefully gone over and these defects rectified, and another set cast from them. This set is also finished and machined, and then assembled in another machine. This latter machine is found to be a great improvement over the first, as all defects and inaccuracies have been rectified and each and every part has been machined as accurately as possible.

The machine now goes to the tool-designer, who is called upon to scheme up and design complete sets of tools, dies, fixtures, and appliances for the machining of all castings in repetition and for the exact duplication of each and every other part, from the largest shaft and gear to the smallest pin and screw. To be capable of accomplishing all this the designer must be—first of all—a practical man, familiar with all mechanical principles necessary to the successful construction of the tools, as well as be possessed of a theoretical knowledge of the properties of all metals. He must design the tools to be both positive and accurate, as well as strong and durable. He must also allow of their being constructed as simple as possible, consistent with accurate production and rapid handling when in operation. He must, lastly, be certain he is right in all measurements down to the smallest fraction of an inch. In fact, he must construct a perfect set of tools for the exact duplication of all the parts of the machine on paper. The designer must also provide for the tools being so constructed as to allow of being handled and operated to their fullest capacity by men of the average skill and intelligence, with rapidity and without the possibility of error. By the time the designer has accomplished all this and gone over and verified all his designs, until he is sure of their accuracy and of their coinciding perfectly where necessary, he has finished his part of the work.

The tool designs and the machine now go to the tool-maker; he has the last, but not least, proposition to tackle. Where the pattern-maker had to produce his designs in wood, the draughtsman his on paper, and the moulder his in sand, the tool-maker has to create his in steel and iron, which can neither be whittled with a knife, nor the parts fastened together with glue, nor the mistakes and inaccuracies rubbed out with an eraser. Neither can the tool-maker shape his work in sand and locate the points with a trowel. He is the man on whom the accuracy, efficiency, and working qualities of the finished product depend. His skill, ingenuity, and powers of creation and production are taxed to their fullest extent indeed; and, unless he is a man of brains, skill, and experience, all work of the designer, pattern-maker, and moulder will have been useless. First in the machining and finishing of the tools and the placing of all locating points, and then in the assembling of the parts, is his knowledge and skill called into play. As each tool, fixture, or device for the production of some special and distinct part is finished, it must be tried and proved; and the piece machined in it must fit exactly in its proper position and coincide perfectly with all other points necessary in the other parts, so that the performance of its separate and distinct motion will be guaranteed. And thus on to the end of the list, until the full set of tools is complete, so that a perfect and complete machine can be constructed by their use, with the certainty that all parts machined in them will be found to interchange perfectly, so that they may be selected haphazard in the assembling of a new machine or in the repairing of an old one. When all the foregoing has been accomplished, the preliminary work necessary to the successful manufacture and perfect operating of the machines in any number desired, with the certainty that each and every one will be an exact duplicate of the others, from the smallest pin or screw to the largest casting, is an accomplished fact. We may now go ahead and manufacture by means of the interchangeable system, which allows of the construction of machinery at the minimum of cost and to the maximum of production; and, what is more, allows of constructing machines in exact duplication of each other, which could not be accomplished by any other means.

THE AMERICAN TOOL-MAKER—THE MOST SKILLED MECHANIC IN THE WORLD.

When all the skill, capacity, and brains utilized in the accomplishment of the mechanical results outlined in the foregoing are considered, is it irrelevant to make the assertion that the genius and intelligence utilized in the inventing, developing, perfecting, and manufacture of machinery are second to none and above most? We think not; and if any one who doubts the truth of it will stroll through a modern machine-shop, of the kind necessary to the production of intricate, labor-saving machinery, and notice the various operations through which the parts used in the construction of such machinery go, and the special tools, fixtures, appliances, arrangements, devices, and machinery used for their production, we think he will change his mind and will be grateful that America and Americans can boast of men who are capable of such things; for it is to such as they, more than all others, that we owe our commercial and industrial supremacy of to-day. The great changes in the last century, which have contributed to the uplifting and betterment of the human race, are marked by the achievements of men whose whole lives and energies have been devoted to the perfection and production of things mechanical. This genius of invention which has conceived, developed, and made possible the manufacture of labor-saving machinery, has multiplied and improved the necessaries as well as the luxuries of life.

We are known and acknowledged to-day as the greatest world power. What has made us so? It is to those who have developed and perfected our modern manufacturing industries that we owe the most. It is because we can view with equanimity the strivings of other nations to outdo us; because we can go out into the markets of the world and meet and overcome their competition, that we are what we are. And how has this come about? Simply through the great inventive ability and ingenuity of American engineers and mechanics. Thus has the production of all articles and necessaries of commerce been cheapened and multiplied. Go into the drawing, construction, or tool department of any of the large machine establishments and note the men employed therein. They will be found to bear favorable comparison with those engaged in any of the other arts or professions. What is more, these men do not stand still, but keep increasing their knowledge, and thus step higher and higher to positions which their ambitions and capacities entitle them. From the ranks of such men come the best of our inventors of machinery, our superintendents and managers.

Before closing this introductory chapter, I will say the industrial supremacy of the United States in the twentieth century has come about through the developing and perfecting of the modern system of interchangeable manufacturing, and will ever stand as a monument to the skill and ingenuity of the American mechanic.

CHAPTER II.

Machine Tools, Designing, Tool-making, and Tool-Rooms.

MACHINE TOOLS.

It has been well said that the foundation of the industrial structure of to-day rests on machine tools; and with this statement, I believe, all who are familiar with the mechanical development of the last decade and have given any thought to industrial betterment will agree. It is a fact, that all must now concede, that without these machine tools, these wonderful factors in modern civilization, we would be reduced to the state of primeval man and be forced to do by hard physical labor that which thousands of automatons now accomplish for us. It is with machine tools that all other machinery is produced; the standard tools of the universal shop, the lathes, drills, planers, shapers, millers, boring-mills, and the numerous minor members of the great family, are all called upon to contribute their share to further economic modern manufacturing.

Now, in view of the afore-mentioned facts, it must be obvious to all that the nation which aims to lead in industrial matters must be the one that possesses the most efficient and best developed machine tools, as the possession of such is a criterion of the mechanical skill and ingenuity of the country's mechanics. Hence where the best machine tools are found there will also be found the best knowledge of how to operate them to the best advantage. Thus we arrive at the conclusion that if good tools are to be made, a comprehensive and broad knowledge of how tools should be used and the amount of work they should do is absolutely essential. Of those who are possessed of this knowledge, it may be said that they are indeed ornaments to their profession, as they stand equipped to produce means which will lighten the load bequeathed by Mother Nature to both man and beast—means for doing the world's work economically and efficiently.

THE DESIGNER.

When considering machine tools we are at once confronted by the fact that the efficiency of any machine, device, arrangement, or tool used in manufacturing is determined solely by the quality and quantity of its output. To some extent this is modified by the skill of the workman using the machine or tool. However, machines and tools should be designed and constructed so that the factor of skill in handling will be ineffective except in contributing to produce a better quality or a greater quantity of work than is demanded in the specifications.

Now in order for the designer to be capable of designing a machine or a tool which will meet modern requirements, he must first be thoroughly practical and familiar with the details of the various lines of manufacture in which his creation is to be employed. A theoretical knowledge of the properties of all materials, under all conditions, must also be possessed by the man who wishes to accomplish things in tool design, before he can hope to solve the innumerable problems which will confront him. When the vast field to be covered is considered, it is plain to all that the task that is set is no ordinary one and that his mental equipment must be very complete in order for him to succeed. It is well that the comparatively limited number of methods employed in the working of metals contribute somewhat to the lightening of his load. These methods may be enumerated as follows: forging, rolling, pressing, turning, drilling, tapping, planing, milling, grinding, punching, shearing, and sawing. This list comprises the most important methods; the rest are minor and may be virtually classified under some one in the above-enumerated list.

THE GREAT PRINCIPLE OF REPRODUCTION.

The designing and constructing of fixtures and special tools to be used in machine tools for modern manufacturing represent the highest application of the great principle of reproduction. It is this subject that we are about to take up, and it comprehends not only the tools known as jigs and fixtures, but all special tools of various types which are in general use to-day for the cheap and accurate production of parts in duplication and repetition, whether of metal or other material. The inception of the grand principle may be traced back almost to the beginning of time.

Perhaps the earliest application of the principle of reproduction was in the moulding of plastic materials which were afterwards baked. From the days of the first use of moulds to the application of the principle in the art of printing was a long step, yet it was in that art that it next found use in printing from hand engravings and afterwards from removable type. Following this, the principle was applied in the making of reproductions of paintings and lithographs, in the coining and stamping of metals, and then in the casting of metals and numerous other materials. In fact, I might go on for pages and trace the application of the principle of reproduction down to to-day, and at length stop at a set of tools for the repetition production of a modern universal milling-machine or a precision-lathe.

The most advanced application of the principle of reproduction in which we are interested is to be found in the use of templets, gauges, jigs, fixtures, and cradles, as those tools are chiefly used in working and cutting parts of metal, to a limited degree of variation, which have been previously roughly formed by the processes of rolling, drawing, forging, or casting.

FUNCTIONS OF JIGS AND FIXTURES.

In jigs and fixtures their functions are often combined with those of machines in which they are used, such as a machine of special design fitted for operating on parts of the same size and shape, the work being located and the tools operated by devices self contained in the machine. This we find in a multiple spindle drill, which has been specially equipped for drilling all holes in a part of a machine or in a large plate, the drill-spindle cases being rigidly fixed in position in a certain relation to each other. In a machine of this type the position of the drill spindles represent the jig, as it is only necessary to place the work on the table and the holes may be drilled in the same position as those in the preceding piece.

TEMPLETS.

Templets are tools made of flat pieces of metal, usually sheet metal, which are used to lay upon surfaces and are located by the eye, fingers, or fixed flanges or pins, etc., so that certain edges of the templet, outside or inside, may be used as a guide for scribing outlines of them on the surfaces of the work—the outlines to serve as guides for drilling holes, cutting grooves below the general surface, or for forming the outer or inner edges of the part to the external or internal outlines of the templet. Thus a tool of this kind reproduces marked lines with accuracy to a degree dependable upon the care taken by the user. The working to those lines afterwards, however, is subject to variable error, as much depends upon the skill of the workman.

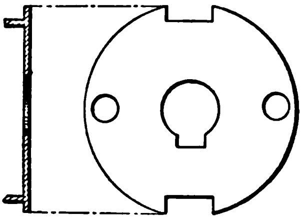


FIG. 1.

As an illustration, let us say that we make a templet of considerable thickness and secure it firmly to the work, so as to allow of using the locating edges for actual guides for the cutting tools —take Figs. 1 and 2, for instance. By doing this we get the simplest form of flat jig. When the outside edges of such a templet are used to locate finished edges in the work, the tool bceomes either a filing, milling, shaping, or planing jig, as the case may be. The most usual use of a flat jig, however, is to locate cylindrical holes of various sizes and kinds to be drilled with drills or other similar tools, or to locate grooves, angles, or keyways in parts in certain relative positions with other finishing points. Fig. 3 illustrates a die templet.

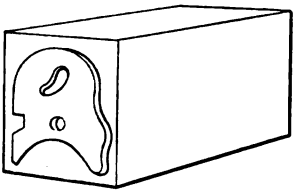


FIG. 2.

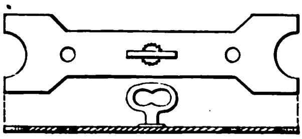


FIG. 3.

GAUGES.

In gauges, their general function is to verify standard measurements between points and locations. While the use of such tools is well enough known to make a detailed description of them superfluous, a few remarks are essential. In accurate work "limit" (Fig. 4) gauges are frequently used. One gauge represents the maximum of allowable inaccuracy and the other the maximum of accuracy required—the work coming within these allowable limits. Thus we see that the purpose of gauges is not so much to locate the points of the various finished surfaces in a piece of work, as to inspect them after they are so located.

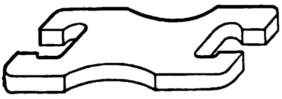


FIG. 4.

FLAT JIGS.

In regard to flat jigs it may be said that the simplest form consists usually of a flat plate of iron, through which certain holes have been accurately located and carefully drilled; the upper and lower surfaces of the plate having first, of course, been machined true. Thus if a flat jig is in the form of a square, or of rectangular shape, and of considerable thickness, as shown in Fig. 5, or, in other words, of the same shape and size as the parts which are to be drilled, it may be clamped in position on a drill-press table and a pair of parallels used to set against two of its edges, the parallels being set at right angles to each other and clamped when the drill has been set to enter one of the holes to the depth required, or all the way through, whichever may be the case. After this has been done the model or flat jig may be

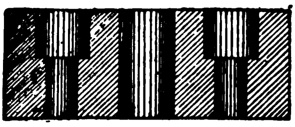


FIG. 5.

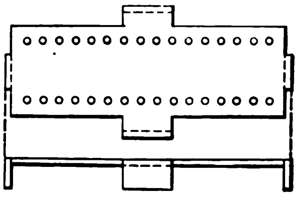


FIG. 6.

removed and the parts drilled in exact duplication of it by setting them against the parallels and clamping them and then drilling. Then again the flat jig may be made to fit the top of the work and the holes drilled by guiding the drill through those in the jig.

A type of flat jig most generally used is shown in Fig. 7. They are usually equipped with downward projecting lugs or pins, which are used to locate the jig on the work, thus obviating the necessity of depending on the hand or fingers of the operator for the locating. Very often devices, such as screws, clamps, or other fasteners, are contained in the jig (Fig. 8), being located upon one or more sides of the jig, the same serving to pull the jig in one or two directions against the work. Where the work varies in size or shape, such as in castings, the clamping is usually central and made to operate in all directions, so as to compensate for the degree of variation in the castings.

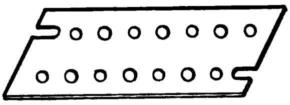


FIG. 7.

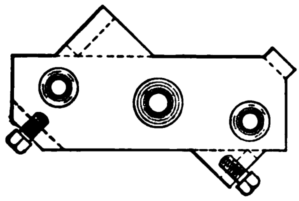


FIG. 8.

BOX-JIGS.

In the further development of the reproducing principle, we come to the box-jig. This type of jig stands upon its own bottom when in use, the work being dropped into it and located by suitable means against stops and down on bosses on the sides of the jig and on the inner surface of its bottom. A jig of this kind is usually equipped with a lid in which the bushings for guiding the drills are located. Very often the work is located and fastened within such jigs by merely dropping the lid down and fastening it. When all holes to be drilled in a box-jig are to be parallel to each other, the jig always stands upon its bottom while in use; but when holes are to be drilled at right angles, from the top and sides or from any of the six sides of the jig, it is necessary that all opposite sides from which drilling is to be done should be provided with surfaces for resting the jig on the table. These resting surfaces or "bottoms" may be at any desired angle to each other, may be cast with the jig body and machined and squared, or be of steel and screwed or forced in.

Box-jigs of the most common types are frequently used for drilling all holes in frames of small machines, standards, or other similar parts. The work is put into the jig and located by certain surfaces which are most favorable for producing uniformity. After the work is located the jig is placed on the table of a gang drill and all holes finished as desired; drilling, counter-boring, boring, or reaming, as may be desired, each spindle of the drill being equipped with the proper tools to accomplish the operation required. Thus by the use of such jigs unskilled labor may be employed for drilling any number of accurately spaced holes in thousands of pieces, with the certainty that interchangeability will be assured. As the jig may be constructed so as to be easy to manipulate while sliding it from one spindle to another or turning it on its different sides, the physical exertion required of the operator is not great; therefore the work is accomplished accurately with ease mentally and physically.

Again, we will often find the box-jig in simpler form, the general shape being flat with a number of lugs or legs projecting downward. With a jig of this sort the lower surface of the lugs serve as legs, the work being clamped up against the lower surface of the jig body. Then, again, there is still another type, which might properly be called a "skeleton" jig, from the fact that it is merely a light skeleton frame in form. It is for very heavy work that these skeleton jigs are used, weight being a considerable factor, and in order for the operator to be able to handle the combined jig and work without undue exertion the jig must be made as light as possible.

WORK THAT SHOULD NOT BE JIGGED—JIGS FOR HEAVY WORK.

While most machine work can be "jigged" to advantage, there is some that it would be obviously impracticable to handle in this way; such as machine bases of large size, lathe beds, large press frames, etc. On the contrary, it is always well to continue doing all necessary work on such parts, such as turning, planing, and milling, by the ordinary methods; using templets and gauges for locating the finished surfaces, and then afterwards using small local jigs or templets for locating necessary holes from some of the already finished surfaces. When jigs are used for such work they should be made for locating only one hole or for locating two or a number of them which are to be placed close together. When such jigs are made small enough, they may be handled with ease and located in succession on various parts of the work.

While the saving of weight is very important in making large jigs in order to allow of their easy handling, it must not be carried too far. It is absolutely necessary in jigs for heavy work that lightness be combined with stiffness, and this can only be brought about through careful designing. Very often large jigs have been carefully made which, when fastened to the work, would bend or twist, thus throwing the holes and locating points out of place, the cause being inattention on the part of the designer to the factor of stiffness.

For the frames of large jigs it will usually be found best to use cast iron, as with this metal the working parts will maintain their position without warping or bending; in fact, they will remain positive until a sufficient strain has been brought to bear on them to crack them. When bodies of such jigs are made of steel castings, forgings, or brass, they often become inaccurate, and these defects are not usually discovered until a large quantity of valuable work has been spoiled by their use.

CHEAP JIGS.

For small quantities of work cheap jigs are sometimes used. They are made by simply drilling the working holes through the body of the cast iron or steel plate of which they are made. Of course, jigs of this construction are not very durable, as the drills wear the holes and the alignment is not maintained. Then, again, such jigs are made by fastening a hardened steel plate in which the proper working holes have been drilled to the frame of the jig. However, the use of hardened steel plates for the purpose designed is somewhat interdicted by the warping of the steel in hardening, thus destroying the alignment and displacing the holes in their relation to each other.

ACCURATE JIGS.

When large quantities of accurate work are to be done in jigs, the tools, of course, should be carefully made. In such jigs drill guiding holes should always be bushed with hardened, lapped, and ground steel bushings, made to standard external diameters, so that they may be easily replaced when the inside has been worn by the revolving of the drills while working. Such bushings are usually forced tightly into reamed holes in the jig bodies. For producing accurate work in small quantities interchangeable bushings are used, a full set of them being kept on hand. These bushings may be used in any of the large jigs in the shop indiscriminately.

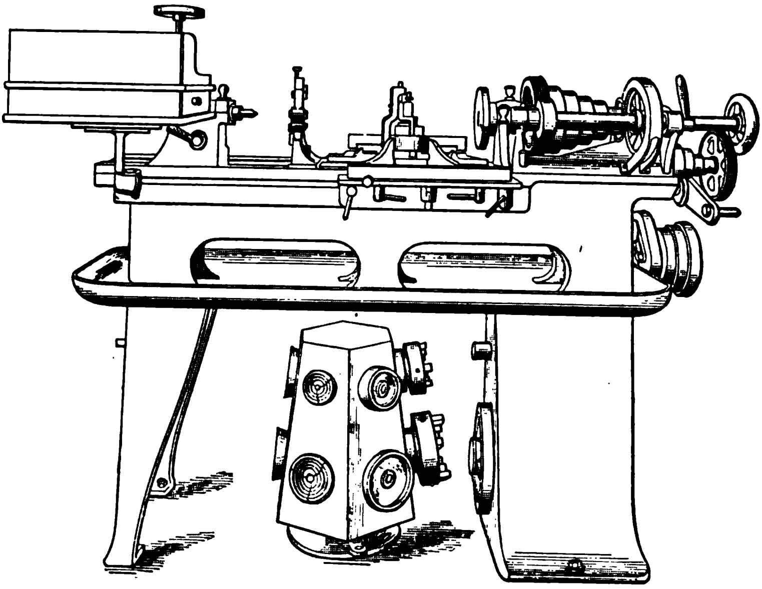


FIG. 9.

TOOL-ROOMS AND THEIR EQUIPMENT.

Naturally, in a chapter devoted to the value of tools and the evolution and development of tool-making, one expects to find something on tool-rooms; at all events, a few remarks on the subject will be timely.

Tool-rooms are of two classes—those in which tools and fixtures are made and those in which they are kept. In those of the first class the most important item is the lathe. An approved type of a modern tool-maker's lathe is shown in Figs. 9 and 10,

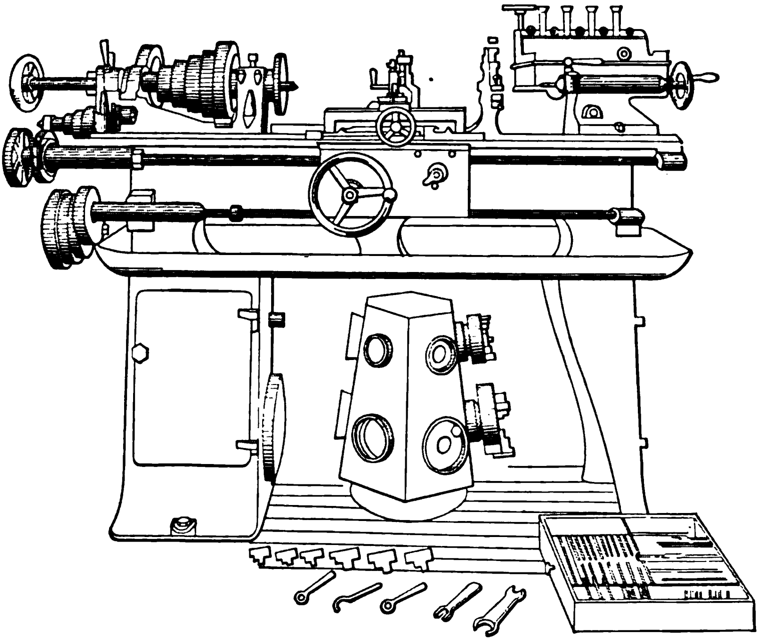


FIG. 10.

the general features of which are apparent. It is a ten-inch, tool-maker's lathe, and its design and construction represent the attainment of perfect and complete convenience. It is one of the most complete precision-lathes ever produced for the tool-maker or model-maker. Now, of all machine tools, for either tool-making or manufacturing, the lathe is king. If a machine-shop or a tool-room is to have only one tool in it, it is obvious to all that the tool should be a lathe, and it should be a good lathe. With a good lathe and a skilled mechanic to operate it and bring out all its capabilities, almost anything in the line of tool-making and machine construction may be accomplished. As to-day lathes are being built in the most astonishing variety of capacities, from the delicate precision-lathe to the ponderous three-hundred tons gun-lathe, no difficulties should be experienced in procuring one for any special line of tool-making or manufacturing.

After the lathe, next in importance comes the drill-press, the selection of which depends upon the class of work to be done. Usually there should be two—a small sensitive drill and a large column machine. Next we have the universal milling-machine, with its boundless possibilities. In order of importance the shaper and planer come next, and in their choice the nature of the work to be done is also the chief factor to be considered. Vises and small tools, of course, follow; then the speed-lathe, for hand-tooling, polishing, and lapping. Lastly, the modern tool-room is not complete without a tool-grinder. All of these machines are sufficiently well known and a detailed description of any would only take up valuable space.

In regard to a tool-room of the second class, it must be obvious to all that its chief requisites are that it shall form a convenient place where tools and appliances may be systematically and handily distributed. In a small establishment only one tool-room is necessary, but in any extensive establishment, where there are several buildings and several floors in each building, it is necessary that there shall be a number of tool-rooms in order that there shall be convenience in the distribution of the tools.

In order that the reader may understand what a tool-room should be like, it is essential that a short description of a model one should be presented. I know of no better way of doing this than by describing those in the shops of Brown & Sharpe, Providence, R. I., U. S. A. In their shops the different tool-rooms are much alike, the largest one being on the second floor of the main building, where all lathe tools are ground on a Seller's grinder before being given out, and other work of like character done. Like all shops in which large numbers and varieties of tools are in use, the check system is in use. Ten checks are given each workman, one of which is placed opposite the place reserved for any tool that he has out. One noticeable and excellent feature of these tool-rooms is the good supply of parallels in each. To save checks, when a workman requires several parallels the system shown in Fig. 11 is in use. The parallels are placed in pigeon-holes, those of one size in one row, the next larger in a row below, and so on. At the right is a board, on the side of which is marked the size of the parallels in each row, and at the top of which are the numbers 1 to 6, to indicate the number of parallels in use. Checks in the positions shown would indicate that a workman had out four 1½-inch parallels and three 2¾-inch ones.

In a great many shops it is common to keep the tool-rooms supplied with sets of taps and tap-drills together in two blocks,

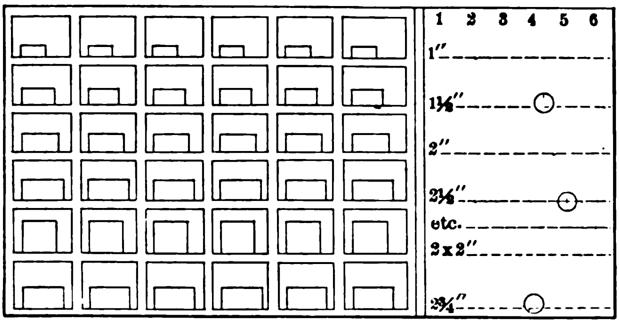


FIG. 11.

only one check being necessary to secure the whole. In the Brown & Sharpe tool-rooms the tap blocks are more completely equipped than usual. Each set or block consists of a full set of drill, tap-drill, starting, sizing, and bottom-tap, two counter-bores for holes where countersunk head-screws are used, one counter-bore having a tip the size of a standard hole and the other to fit a tap-drill hole; each block also contains a test plug, giving the size of a standard head for screws of that size and a tap-wrench.

In regard to keeping track of workmen's supplies, there is a novel system in use. It consists of a six-sided case, one in each tool-room, on the sides of which hang an extra size of ten checks for each man. The top of the case is divided into several compartments, marked, respectively, "Oil," "Waste," "Towels," "Emery Cloth,".etc., and when a man wants a ball of waste one of his checks is dropped into the receptacle bearing this name. Thus after a certain time has elapsed the checks may be removed, counted, and a record taken of the amount of supplies which each man has used. The checks are then put back on their pins.

CHAPTER III.

Fundamental Principles, Processses and Practical Points for Jig Design and Construction.

BEFORE taking up the various types of jigs and fixtures used for the production of repetition parts by drilling and milling, and illustrating them and describing their construction and use in detail, I have thought best to devote a chapter to a presentation of the fundamental principles, various processes, and practical points which are required to be understood in order to successfully design and construct drilling jigs and fixtures or similar special tools used for the machining and duplication of machine parts. If the rules laid down are followed, much unnecessary labor and expense will be avoided and the best of results attained. The descriptions are given from an entirely practical point of view, the theoretical not being touched upon and anything purely speculative being omitted.

FACTORS INVOLVED.

In the first place, let it be understood that there is no one other branch of the machine business that requires more thought, wider knowledge, and broader experience of shop conditions than the designing of jigs and fixtures, and in order for one to be competent to do this work successfully he must possess this essential knowledge of shop conditions. To those who are not so equipped a close study of the chief factors and the fundamental principles involved will be of untold value.

In jig and fixture work there are six highly important factors to be considered: 1. The course the work is to follow during manufacture. 2. The locating and securing of the work in the fixtures. 3. Keeping of the locating points for the work free from chips and dirt. 4. Self-contained tools. 5. The class of help that will use the tools. 6. Convenience and ease in handling the tools during their operation.

Taking the first factor—the course of the work during manufacture—we will say that a part of a machine is given us to design tools for its production in repetition. Now say that the part, in order to complete it, will have to go through two operations, drilling and milling. The question is which should be done first, the drilling or the milling?

In most cases where the part is to be drilled and milled, it is best to provide for doing the milling first; because it is desirable that the drilled holes and milled surfaces shall bear a certain definite relation to each other, and because by having the holes drilled from a milled surface greater accuracy and interchangeability in the parts can be obtained than if the milling were attempted after the drilling of the holes. However, in order to decide the question, a "working point or surface" must be decided upon. Whether the part to be machined is a casting or not, there is always one point which from its position—that is, in relation to others—should be taken as a "working point," a point to work from and refer to in all subsequent operations required to manufacture the particular part. The point chosen may be a hole, a plain surface, a slot, or a lug or a boss—it matters not.

THE LOCATING AND HOLDING DEVICES.

Now having chosen the working point, it follows that this is the point to be machined first, and that the first jig or fixture to be made is the one for this operation. This is the secret of successful jig-making. Also use this point for the locating of the work in the different jigs and fixtures for subsequent operations. Never change a working point, as the performing of one operation from one point and the next from another is not conducive to good results.

When designing fixtures for drop-forgings, turned work, punch-blanks, or any part that has been previously put through a cutting, abrading, compressing, or forming operation, the contour of the part is usually such that the holding of it is a simple matter, especially if the first operation is to be a milling cut. With castings, however, through their lack of uniformity in many cases, fixtures of intricate and costly design are required, thus necessitating considerable care and judgment in the devising of the locating and holding means. If, instead of milling, it is decided that the drilling should be done first, and that the holes so produced are to be used in locating and securing the work instead of using the outline, it will be found that a simpler and less costly fixture can be used. Whichever course is decided upon, the fixtures should be so designed as to allow of all operations of one class being completed before commencing on another class.

Now in regard to locating and securing the work quickly, accurately, and easily, these are factors of the greatest importance, and it is difficult to discuss them properly, for the efficiency of the finished work depends more than anything else upon them.

The various methods in universal use for locating and fastening the work to be machined in jigs and fixtures, such as bunters, cams, set screws, spring pins, slides, flat taper pins, etc., are well known, and I will not attempt to lay down a general rule for their application, as this must be decided by the designer according to the type of fixture and the nature of the work.

One of the most essential conditions necessary to the accurate and rapid production of work in jigs and fixtures is convenience in keeping the locating point free from dirt. This must be evident to any one at all familiar with the use and object of such tools.

When I state that tools should be self-contained, I mean that all devices and means utilized in the locating and securing of the work should be component parts of the tool. When this is the case, the operator is not obliged to use a hammer, wrench, or any other tool in order to operate the fixture.

SIMPLE DRILLING-JIGS.

When drill-jigs of the comparatively simple types are to be constructed for the machining of parts in which no great accuracy is required, the main point to be considered is the interchangeability required in the work after it is machined. With this point constantly in mind, the avoiding of all unnecessary expense and labor will not be difficult. In the construction of simple jigs, which are to be used for the drilling of parts which have been first finished at one or more points, or for rough castings which have not had any previous machining, the most essential points necessary to their successful construction and use are as follows: First, in making the patterns construct them so as to leave openings in the castings at all points wherever possible, without affecting the strength or rigidity of the castings when finished, for the escape of the chips and dirt. Second, provide spots with just surface enough to allow of their rapid surfacing. Lastly, so design the jig as to allow of the expeditious fastening and locating of the work and its removal when finished, as this is one of the important factors in the operation of such tools.

CONSTRUCTING SIMPLE JIGS.

When constructing, after having done the preliminary machining of all necessary outside points, choose the most reliable and positive points for locating the work. First, a machined surface for the positive points for locating. When this is not possible, those points in which the minimum of variation is to be expected in the castings should be chosen. Then, in the fastening of the work within the jig, use means which will be the quickest in operation consistent with all possible simplicity. As there are any number of simple and inexpensive devices which can be adopted to allow this, it should not be difficult.

One point which cannot be too strongly impressed on the designer of simple jigs is to allow excess of metal at as few points as possible; that is, only at the locating and squaring surfaces. The all too prevalent habit of leaving unnecessary surfaces to be finished is expensive and not consistent with satisfactory results.

PROCESSES OF ACCURATE JIG-MAKING.

When drill-jigs are to be made for the drilling of work in which the utmost accuracy is desired, the locating and finishing of the bushing-holes is of the greatest importance, and for that reason I give here descriptions of the most rapid and practical methods for the accomplishment of this part of the work.

THE BUTTON METHOD FOR LOCATING DRILL BUSHING-HOLES.

In the first place, if the jig to be made is of the box type—which is the most generally used type—for which the body casting has been secured, after all sides and bearing surfaces have been planed or milled square and true with each other, including the feet, it should be rested on a surface plate, as shown in Fig. 12, which should be used only for work of this class. If the feet are cast on the jig, they should be scraped until the sides of the body portion are at perfect right angles with their bottoms and until all legs rest perfectly square on the surface plate. If the feet are of tool steel and are screwed into the jig, they should be hardened and lapped on a flat lapping-plate (as shown in Fig. 13), until the same results are accomplished. This preliminary work on the jig is the basis for the successful attaining of all other results, and unless done carefully there is no possibility of the remainder of the work being accomplished accurately.

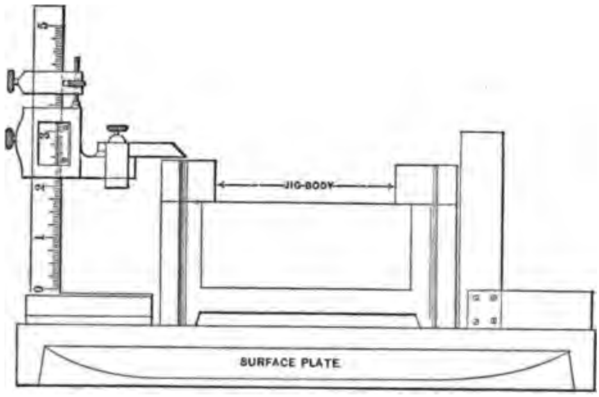


FIG. 12.

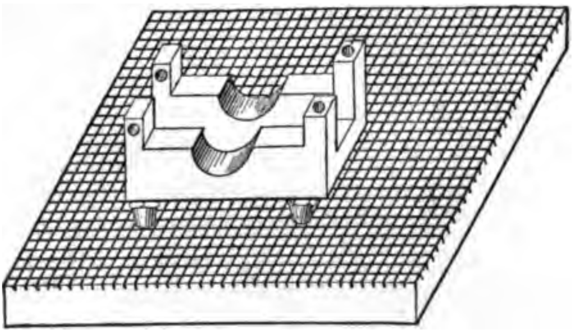


FIG. 13.

For the laying out or locating of the bushing-holes in jigs, and the finishing of them, there are any number of methods in use among tool-makers. Some of these methods allow of fair results being attained, while others are useless, and when accurate or satisfactory results are accomplished though their use it is pure luck, not the method that does it. There is only one method for locating bushing-holes in small and medium-sized jigs accurately and expeditiously.

The following method is used by the best tool-makers on this class of work and is known as the "button method": In shops where jigs for accurate production are constructed, a few sets of locating buttons should be kept in the tool-room as standard sizes—say, five-sixteenths, one-half, and three-fourths inch in diameter, as shown in Fig. 14. They should be of tool-steel and finished to from one-half to one inch in length, and should have a hole through them large enough to allow about three-sixty-fourths inch clearance for the fastening screws, after which they should be hardened and then ground perfectly square on each end, and on the outside to standard size, finally lapping them to get them accurate. One end of the button should be slightly countersunk, so that it will rest squarely on the jig when in position. The centres for the bushing-holes in the jig should next be located approximately correct by the dividers and then prick-punched. They should then be drilled and tapped for the button screws.

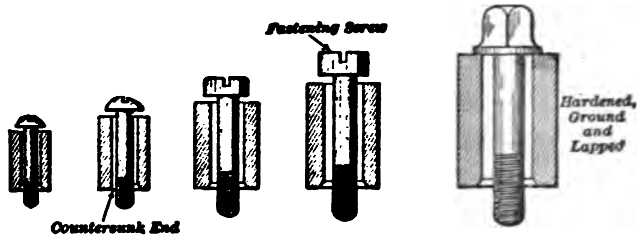


FIG. 14.

To locate the holes positively, first secure a button in position by working from two sides of the jig, using a Brown & Sharpe height-gauge, and fasten it securely by tightening the button screw. Locate the next hole in the same manner, using the height gauge or vernier gauge to get the buttons exactly the proper distance apart and from the sides of the jig, the hole in the buttons being sufficiently large to allow of adjusting them in any direction. After having set the buttons to the number of holes required, and having fastened them securely, as shown in Fig. 15, the finishing of the holes is in order. This may be accomplished by strapping or clamping the jig body or lid, as the case may require, on the lathe face-plate, being careful not to spring it, and then truing the first button by the use of a centre indicator or "wiggler," as shown in Fig. 16. The button should then be removed and the hole bored and reamed to the finish size. Then shift the jig, locate the next button perfectly true, and repeat the boring and reaming operations; and proceed in this manner until all the holes required have been finished. By the use of

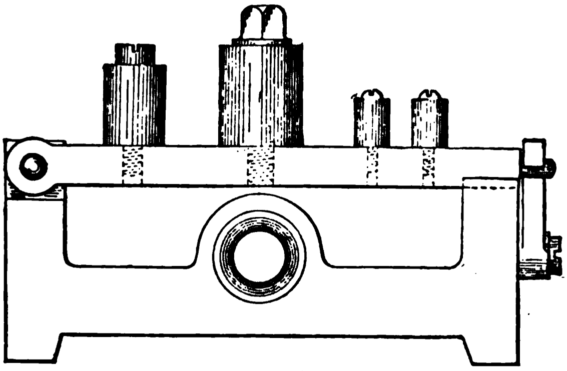


FIG. 15.

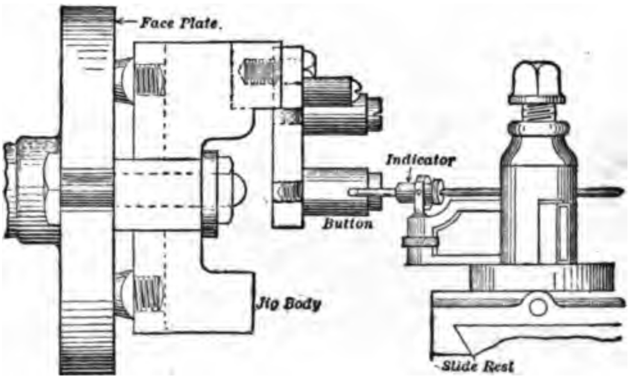


FIG. 16.

this method jigs of the greatest accuracy can be successfully constructed without trouble and worry on the part of the tool-maker, and the results in the castings to be machined in them will be a foregone conclusion.

PATTERNS FOR CASTINGS TO BE JIGGED.

In order to produce good work from intricate jigs, it is absolutely necessary that the castings to be drilled in them should be of uniform size and shape. To insure this, the patterns from which they are cast should be of metal in all cases, finished at all points to the size required; allowing, of course, for shrinkage and surplus stock at all points which are to be machined previous to drilling. When perfect patterns are made there will be no doubt as to the results in the castings.

If the method described in the foregoing for the locating and finishing of the bushing-holes in small jigs of the accurate types were more generally known and used by tool-makers, there would be less worry in the accomplishment of successful results than is at present experienced in the effort to obtain the same by methods which are now obsolete.

Besides the locating and finishing of the bushing-holes in the most accurate manner, the following must be kept in mind in order that satisfactory results will be attained in jig-making. All the various parts of such jigs, including the body castings, should be made sufficiently heavy and strong to withstand all strain to which they may be subjected when in use. The manner of locating the work within the jigs should be such as to be positive and to eliminate the possibility of shifting during the operation of the tools. For instance, it would be ridiculous to adopt a device of the same strength for fastening a piece in which a one-inch hole is to be drilled as would be used for holding a piece in which a one-half-inch hole is required. The means and points chosen for the fastening of the work within the jigs and against the locating points should be such as to allow of rapid manipulation and in no way to interfere with the drilling; and, lastly, the design and construction of the tools should be such as to dispense with all unnecessary parts and labor.

LOCATING AND FINISHING DRILL BUSHING-HOLES IN LARGE JIGS.

The following method of locating and finishing bushing-holes pertains to large jigs. As a rule, the castings of large jigs for machining heavy parts are of considerable size and weight. It is not always possible to swing them on the lathe face-plate and finish the bushing-holes by the "button" method; as the cumbersome shape and unusual size of the body castings interdict the accurate and positive locating of the buttons and make the task wellnigh impossible, we are forced to adopt other means which

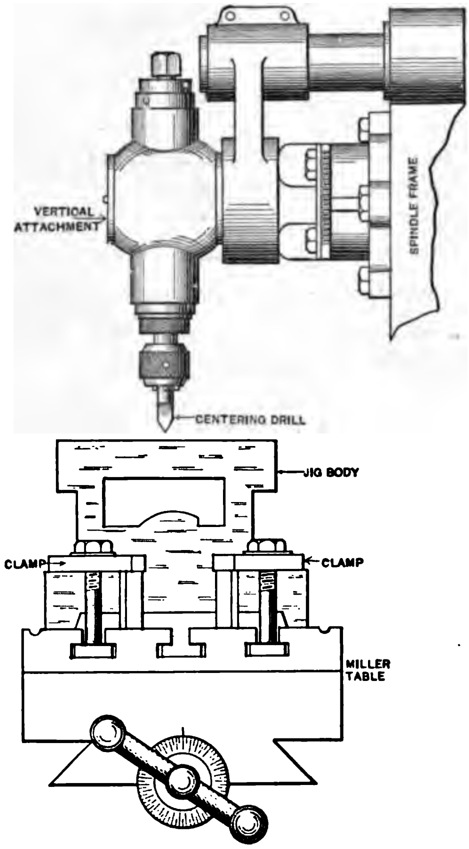


FIG. 17.

will allow of accomplishing the result in an easy manner. To do this we use a universal milling-machine which is equipped with a vertical attachment. First, we strap the jig body on the table

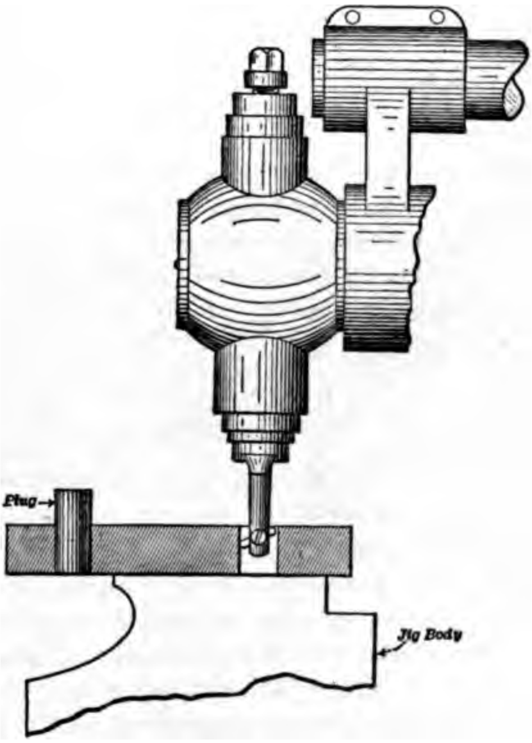


FIG. 18.

and then locate the holes by using the cross and longitudinal feed-screw graduations, the vertical feed, a pair of twelve-inch verniers, and a B. & S. height-gauge. The actual work is accomplished by first locating and finishing the holes in the upper surface of the jig body, using a small drill-chuck, as shown in Fig. 17, located in the socket of the vertical attachment, and a short, stiff, centering drill. We space, centre, and drill the holes to the number required in their approximately correct position, leaving them somewhat under-size and in their accurate location to each other. To size and finish the holes, a spindle should be turned to fit the socket of the vertical attachment and a small cutter inserted in the protruding end of it. Thus we have a small boring-bar, as shown in Fig. 18. We next determine the distance from the side of the boring-bar to the working side of the jig body with verniers. We deduct one-half the diameter of the boring-bar and then move the table by means of the cross and longitudinal feed-screws the distances required in thousandths, and bore the hole to the finish size. The hole being finished we make a plug and fit it to the hole and insert it, and then finish the remaining holes by working from the plug and the side of the jig, measuring with the verniers from the side and from the base with the height-gauge. Afterward we may drill and finish the holes in the other sides of the jig body in the same manner, merely reversing the jig body or removing the vertical attachment and working directly from the miller-spindle, as may be found convenient.

JIG WORK ON THE PLAIN MILLING-MACHINE.

While the most satisfactory and accurate results in jig-making can always be attained on the lathe face-plate by the "button method" or on the table of the universal milling-machine by the vertical attachment, as described in the foregoing, and jobs can be done that would be wellnigh impossible of accomplishment by other means, it must not be inferred that the plain milling-machine is limited in its sphere of usefulness in jig-making. Practice has proven that this machine tool possesses considerable utility in this line.

As the greater number of jigs required are rectangular and have bushing-holes let in parallel with the sides, and not infrequently the bushing-holes are located in all sides of the jig body, with each side used in turn as a bottom to set the jig on when drilling from the opposite side, it will be apparent that a large part of the work necessary to construct the tool can be conveniently done on a plain miller with a table that can be adjusted vertically. We will say that we have a jig to make with bushings let in from two parallel sides. First we square and scrape the bottom locating surfaces and then clamp the jig body on the plain miller-table, setting it square with the spindle and as far from it as possible, so that we may have ample room between it and the work. In some cases it may be expeditious to clamp an angle-plate to the platen at one side of the work square with the spindle, so as to assist in locating the first hole and proving the work as we proceed. If holes are to be put in all of the different sides and the jig is clamped for locating the holes in the second side, the tool-maker can establish without trouble the correct relation between the holes by taking distances from the angle-plate to plugs inserted in the holes first bored, as per Fig. 19. When the distance from the first hole to the side of the jig is determined, we add the distance the jig is from the angle-plate, and thus determine how far the first hole is from the angle-plate.

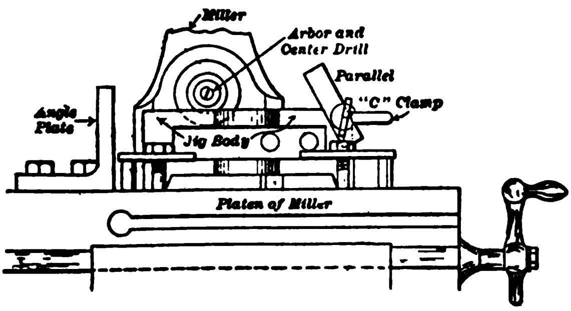


FIG. 19.

With the rest of the work there are a number of ways to follow, but the most practical is to use the height-gauge to measure all distances. Another, that is almost as good, is to insert an arbor in the miller-spindle and feed the table forward until a piece of tissue paper will just draw out between the arbor and the angle-plate. Then by means of the dial on the longitudinal feed-screw run the table forward the required distance. When the screw on the machine has been determined to be correct, one can depend on the dial almost wholly for the vertical spacing, while the platen can be set by calipering to the arbor in the spindle.

In doing jig work on the plain-miller a parallel can often be clamped to the side of the jig, from which measurements may be taken. After the work has been located in place on the table a miller-vise may be clamped to the platen and a diamond-point tool clamped in it, with which the test arbor in the spindle may be turned true, as shown in Fig. 20, finishing it to size convenient to use in locating the work both horizontally and vertically. Then again, a turning-tool may be clamped to the back edge of the table with a parallel spanning the distance to the first slot in the table, and in this way true a piece of stock which may be held in a chuck in the spindle. Any tool-maker who has done much jig work on the miller will appreciate the advantage and the help in having a test piece in the spindle running perfectly true, and that in order to accomplish accurate work it is necessary to have all conditions equally accurate and reliable as the job progresses.

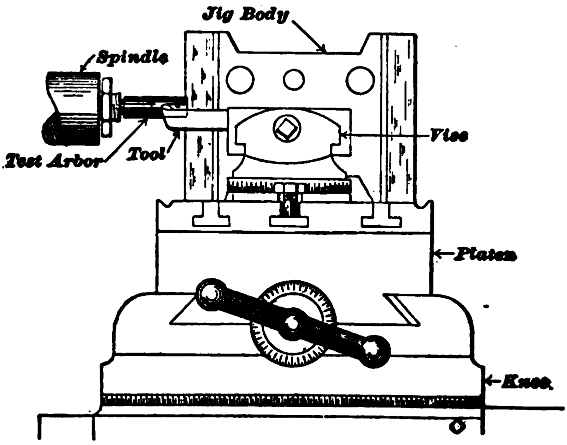


FIG. 20.

It is sometimes necessary to bore a bushing-hole in a jig at an angle with one of its sides. To do this correctly on the plain miller we can set the jig body at the given angle with the angle-plate—which has been first set square with the spindle—by a bevel protracter.

HANDLING LARGE JIG BODIES.

When work is to be handled that is larger than the capacity of the milling-machine platen, it is only necessary to provide an auxiliary platen almost as long as the machine table and about twice its width, and bolt it to the machine. This emergency table should be provided with a number of slots or holes for fastening the work to it. Accurately made parallels which just fit the slots in the table are of great convenience in setting such large work, while a block with a tongue to fit the slot and nearly as wide as the table and with its edge milled accurately in line with the spindle axis is also a help.

After the jig is located and ready for letting in the bushing-hole (whether on the lathe face-plate or on the table of the universal or plain milling-machine), finishing should not be done with drill or reamer, for there will not be one chance in a thousand that the hole will be accurately located. The hole must be bored to a finish in order to do a correct job.

JIG FEET.

The proper feet for jigs is largely a matter of individual taste. There are, I believe, quite as many kinds of jig feet as there are jig designers. Some even go so far as to prefer having no feet at all on their jigs, and thus obviate the possibility of trouble with the drill-press table slots.

Figs. 21 to 30 show a number of different kinds of jig feet. Figs. 21 and 22 are flat-base types; Figs. 23 to 25, cast feet on the base of jigs. Any of these make good feet, the one shown in Fig. 23 being, of course, easier to make and just as good as

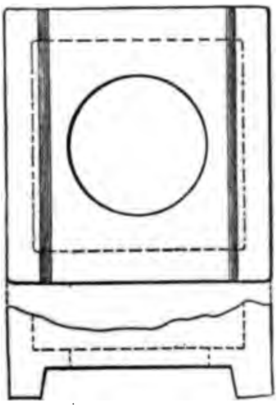


FIG. 21.

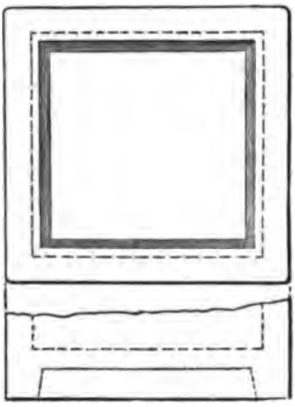


FIG. 22.

the others except where a foot of considerable length is necessary. With steel feet all sorts and sizes are used and give satisfaction. Figs. 26 to 30 are types.

In concluding this chapter it will not be amiss to emphasize the advisability of becoming practically familiar with the installation and operation of the interchangeable system of manufacturing. To demonstrate the necessity of mastering the details of the system, it is only necessary to point out that in the manufacturing machine-shop of the present day the efficiency of the machines or parts turned out can usually be judged by the use that is made of properly designed and constructed drilling and milling fixtures and jigs for the production in repetition of the most accurate operations of the work. Although it has been, and is still, possible to obtain satisfactory results without a large outfit of such tools, no shop can produce interchangeable parts or duplicate machines in large quantities and sell them at a price which will compete in the open market, unless it has an adequate equipment of special jigs and fixtures, and a man at the head of it who thoroughly understands their design, construction, and use.

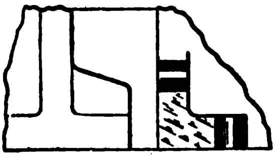


FIG. 23.

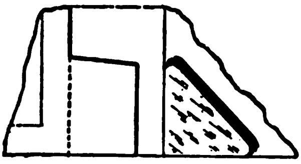


FIG. 24.

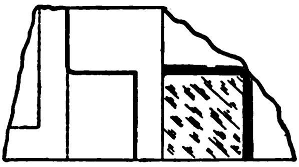
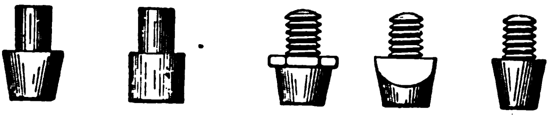


FIG. 25.



FIGS. 26-30.

CHAPTER IV.

Types of Simple and Inexpensive Drilling-Jigs; Their Construction and Use.

In order to discuss the subject of drilling-jigs exhaustively, I think it is best to follow up the chapter devoted to the fundamental principles for such work by first taking up the comparatively simple class of such tools which are used for the machining and duplication of parts in which great accuracy is neither essential nor desirable. As before stated, the main point to be always considered by the constructor of tools of this class is the degree of variation allowable in the work that is to be machined.

TWO TYPES OF VERY SIMPLE DRILLING-JIGS.

Fig. 31 is a plain casting with two ribs cast on one side. The casting is first planed on the sides *A A*, and a cut is also taken off the ribs. It is then ready to be drilled. As the holes to be drilled are clearance holes for bolts and studs, no great accuracy in the jig is required. The jig for this casting is shown in three views in Fig. 32, and, as will be seen, is about as simple and inexpensive to construct as could be devised for the work. It consists of one body casting, *D*, with six projections on one side for the locating-points and fastening-screws. It is first planed on the top and then strapped on an angle-plate on the miller-table, and the inside is milled. The inside of the projections *F* and *E E* are finished square with each other, as they are the locating-points. Holes are then drilled for the set-screws *J* and *I I* in the lugs *G G* and *H* respectively. These screws are case-hardened. In locating the

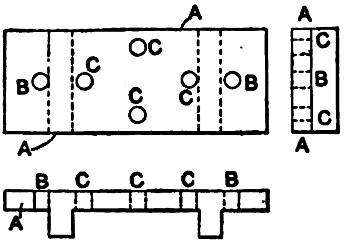


FIG. 31.

holes for the bushings, a casting, planed and ready to be drilled, is laid out, and the holes are drilled and reamed in the position and to the size necessary, so that they will coincide with those in the part of the machine on which the casting is to be fastened. This casting is then used as a templet, and by means of the screws *J* and *I I* fastened within the jig. The holes are then transferred through it to the jig, enlarged, and reamed to size. The bushings *L L L L* and *K K* are then made, and hardened, lapped, and ground to size, and finally driven into the jig. The castings are drilled by fastening them within the jig and resting them on the face of the ribs. This jig is easy to handle and is a rapid producer.

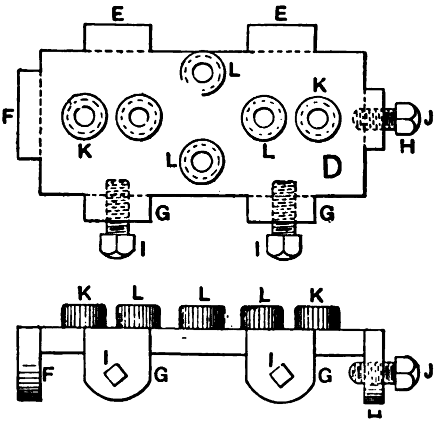


Fig. 32.

The jig used for drilling the holes *P P* and *O O*, in the casting Fig. 33, is of a different type and is known as a "box-jig." It is in design one of the simplest and most reliable of jigs suitable for drilling work of the class shown, where holes have to be drilled at right angles to each other. The casting Fig. 34 is machined at one point only, *M M*, before drilling, by means of a gang of mills, the size being exact and the ends square. This milled surface is utilized as a locating-seat for the work when being drilled. The jig Fig. 34 is in two parts—the body or box casting *A* and the lid *E*. The body casting is first planed square on all sides, and the inside at *C C* finished off to fit the milled portion of the casting at *M M*. A cut is also taken off the back at *D* for the side-locating point for the work. The lid *E* is fastened to the body casting at each end by means of the screws and dowel-pins. Two holes are then drilled and reamed through the lid *E* and the base *A* for the taper locking-pins *I I*, which are of Stubs steel and are milled flat on one side and hardened. The centres for the two bushings *G G* in the side of the jig, and the four *H H H H* in the lid are accurately located by setting the jig on the surface-plate and locating the centres by the use of a Brown & Sharpe height-gauge. The centres are then prick-punched, and circles, of the diameter to which the holes are to be finished, struck around them with the dividers. Now when holes are to be bored an exact distance apart—that is, to the smallest possible fraction of an inch—the only way to accomplish this successfully is to use buttons and to strap the jig on the face-plate of the lathe, and accurately locate them by means of an indicator; but in a jig where a generous limit of error is allowed, as in this case, a simple and more expedient means may

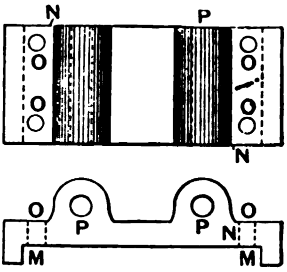


FIG. 33.

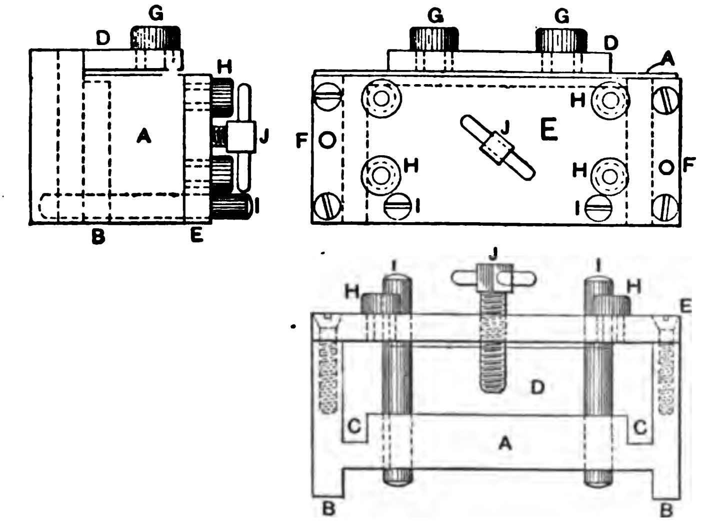


FIG. 34.

be used. The best and most reliable way is to strap the jig on the table of the miller and locate the drill true and central with the reference hole, after which the other holes may be located by moving the table forward or backward, or raising it the proper distance, by means of the dial on the feed-screws. In fact, all bushing-holes in jigs of this kind should be drilled in this manner, and not on the drill-press, as it is pure luck when satisfactory results are attained with the latter method, and that factor is a poor and unreliable one to depend on. After the bushings are made, hardened, and driven into their respective positions, as shown, and the clamping-screw *J* made and entered into the lid *E*, the jig is complete.

To use the jig the casting Fig. 33 is slipped into it so that the points *M M* are located at *C C* in the jig. The clamping-screw *J* is then tightened and the two taper-pins entered with the flat face of each against the work, and each given a sharp blow with the hammer to locate and hold the work tightly and positively in position. The jig is then stood up on the legs *B B*, and the four holes *O O O O* are drilled. It is then turned on its side, and the two holes *P P*, Fig. 33, are drilled. The clamping-pins *I I* are driven out and the screw *J* loosened, the finished work removed, and another casting inserted. The use of the taper locking-pins *I I*, as shown, is one of the quickest and most positive means for the fastening and locating of work of the class here mentioned.

The two jigs described embody in design and construction a number of different practical points which can be adapted for use in jigs for the drilling of parts which have first been finished at one or more points, as well as rough castings which have not been finished at all before being drilled. Of course, for the latter class of work, except in special cases, jigs of the simplest and most primitive design are all that is necessary, and they are not worthy of a detailed description.

A SIMPLE FOURTEEN-HOLE DRILLING-JIG.

Fig. 35 shows a casting used as a leg of a small automatic machine, and the jig for drilling the holes in this casting is of a more accurate and complicated design than the two previously shown, as the holes drilled in the bosses *A B C D* are for shafts, and must be exactly the proper distance apart for the gears, which are afterward assembled on the shafts, to mesh properly. The casting, Fig. 35, is first machined to size at four points, namely, at the top and bottom and both sides of the bosses. In all there are fourteen holes to be drilled, in the positions shown.

The jig used in drilling the holes is illustrated in three views in Fig. 36. Fig. 37 is a plan of the jig. These show clearly the design and construction, and very little description is necessary.

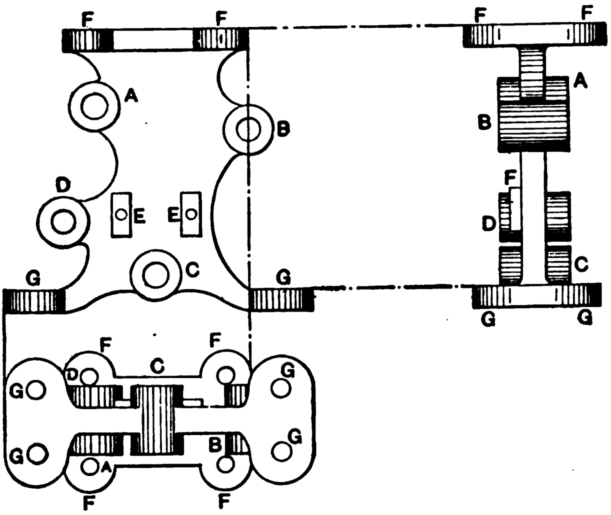
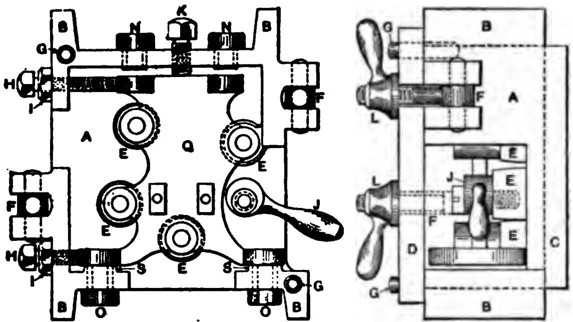


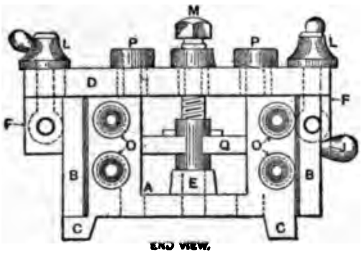
FIG. 35.

The jig proper *A* is of the box type, and is made with the removable lid *D*. It is cast with legs on three sides—at both ends, at *B B*, and at the bottom, at *C C*. All sides are first machined square. On the inside of the jig, at *E E E E*, are raised spots for the work to rest on. This allows of quickly finishing the inside, by merely milling the face of the spots to the height desired. The locating-points for the work are four; the two adjustable locating-screws *H H*, which are equipped with jam-nuts *I I*, and the points at *S S*. The adjustable screws should always be used when castings of the kind shown are to be drilled, as any variation in the different lots of castings may be quickly accommodated by adjusting the screws. For locking and fastening the work against the locating-points, and within the jig, two set-screws, *K* and *M* respectively, and the eccentric clamping-lever *J* are used. The set-screw *M* holds the casting squarely on the raised spots in the jig, and that of *K* forces it against the points at *S S*, while by giving the lever *J* a sharp turn it forces the casting against the screws *H H* and locks it in position, thereby holding the work securely without danger of loosening while being drilled. The eccentric clamping-lever is rapid in both fastening and releasing the work. The lid *D* is located on the jig by means of the dowel-pins *G G*, as shown in Fig. 38, and fastened securely by the swinging clamps *L L*.



PLAN VIEW WITH LID OFF, SHOWING MANNER OF LOCATING, AND HOLDING WORK.

SIDE VIEW.



END VIEW.

FIG. 36.

In this jig the holes for the bushings at either end, for drilling the holes marked *G* and *F* respectively in the work Fig. 35, are drilled in the milling-machine in the same manner used for the other jigs. But for the shaft-holes *A B C* and *D*, after the buttons are accurately located, the lid *D*, Fig. 37, is strapped on the lathe face-plate, and each "button" positively located with an indicator, and the holes bored and reamed to the finish size for the bushings *P P P P* and *R R* respectively.

When using the jig the lid *D* is removed and the casting inserted within the jig, as shown as *Q*, Fig. 36. The lid *D* is then replaced, locating on the dowel-pins *G G*, and the swinging clamps *L L* are tightened. The set-screw *M* is also tightened and the eccentric lever *J* given a sharp turn to locate the casting tightly in position. The holes at either end are drilled by resting the jig on the legs *B B*. The casting is then rested on the legs *C C*, and the six holes in the side are drilled. The removal of the finished work may be quickly accomplished by loosening the set-screws *K* and *M* and the lever *J*, and then removing the lid *D*.

The three jigs shown and described in the foregoing will serve as practical illustrations of three separate and distinct types of jigs, and show how, by the use of simple and inexpensive tools, uniform and satisfactory results may be obtained at the minimum of cost and to the maximum of production in the machining of parts in which, as stated before, a limit of error is allowed.

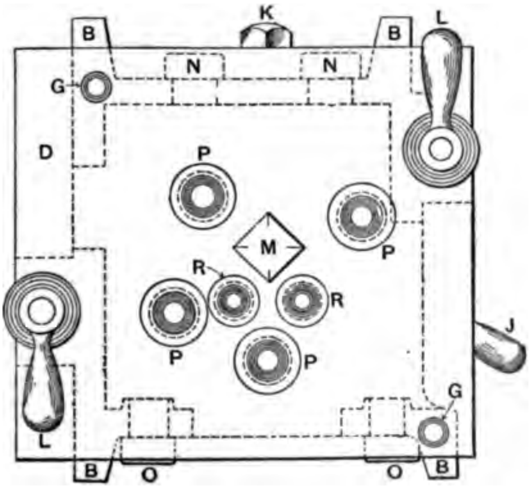


FIG. 37.

JIGS FOR A BEARING-BRACKET AND BEARING.

Fig. 38 shows a casting of aluminum, used as the upper bearing bracket of an electric cloth-cutting machine. After the hole in the centre had been bored and reamed to fit the bearing, Fig. 40, at *K*, it was faced off on the front and back. The holes in the wings were to be all interchangeable with those in the motor-case of the machine. The four holes around the centre were also to be interchangeable with those in the bearing, Fig. 39. All these holes were drilled in the jig Fig. 40. This was made in two parts, the base *A* and the lid *B*. For these patterns and castings were made. There were four bosses in the bottom for the work to rest on while drilling. After the base *A* had been faced off on the back, it was strapped in the miller and a cut taken over the bosses and also over the ends on which the lid rested. A hole was then drilled in the centre of the base, into which a plug, *E*, of tool steel, turned to fit the centre hole in the work (Fig. 39), was driven. The work was then placed on it and the stop-pin *G* let in. The set-screw *R* having been made, a hole was drilled and tapped and the screw let in.

The lid *B*, of cast-iron, after being planed on both sides was strapped to the top of *A*, and holes were drilled for the two dowel-pins *C C*, which were then let through into *A*, and the holes in *B* eased up so that the lid would set in nicely. *A* and *B* were then clamped together and a slot milled through each end for the locking-posts *I I*. The posts were made and finished and hinged in *A* by pins *J J*. Thumb-nuts were got out and tapped to screw on to the posts freely. The posts were then swung over

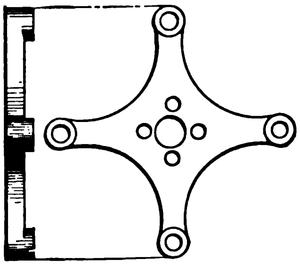


FIG. 38.

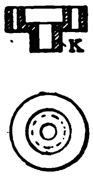


FIG. 39.

and the thumb-nuts tightened, thereby clamping the lid and base together. The jig was then stood up on the side *D*, which had been squared with the back, and the centre of the stud *E* was found on the lid *B* with a height-gauge, the holes for the bushings were laid out; centred, drilled, and reamed, and the bushings made, hardened, ground, and driven in. The jig was then complete, and lid was removed, and the work (Fig. 38), was inserted, centring itself on the stud *E*. The set-screw *R* was tightened until the work was forced up against the stop-pin *G*, the lid *B* was replaced, the dowel-pins *C C* locating it, the lock-posts were swung up, the nuts tightened, and all the holes drilled, which completed the operation. As will be seen, there is just enough space between the bottom of the lid and the work for clearance, which was all that was necessary. The centre holes in the castings being reamed to the size and as nearly as possible in the centre, thereby fitting the stud *E*, and the castings being of uniform size, they were easy to handle. The stop-pin *G* and the screw *R* were sufficient for all requirements of location. Clearance-holes were drilled in the bosses on which the work rested, to allow an easy escape for the drillings.

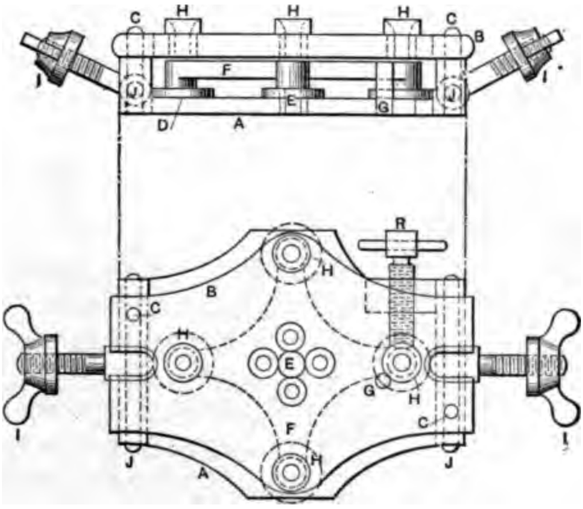


FIG. 40.

Fig. 41 shows the jig used for drilling the four holes in the bearing, Fig. 39. As stated before, they had to match those to the bracket, Fig. 38. The bearing itself was of tool steel, turned and finished all over to fit the centre hole in Fig. 38. The jig for drilling was of the box type, made in two sections. *L* was the base or jig proper, of round machinery steel, a piece of which was chucked and turned on the outside and a hole bored and reamed to just fit the work at *K*. It was secured and a thread of a coarse pitch cut, leaving only two threads. It was then faced off and undercut at the bottom, to allow the work *O* to set in, as shown. The lid *P* was turned and threaded to fit the piece *L* nicely; it was also counterbored to go over the work and clamp the face when screwed down solid. The outer edge was heavily knurled to give a good grip. The work (Fig. 39), was inserted into one of the finished pieces (Fig. 38), and the four holes were transferred through it, when it was removed and inserted in the jig *L* and used as a templet, and the holes drilled through it and through the bottom of the jig *L*. The top *P* was then screwed on and the holes transferred to it. Then they were enlarged for the bushings, which were made and driven in. This finished the jig. The work being inserted, the cap was screwed down and the holes were drilled.

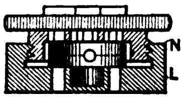


FIG. 41.

TWO SIMPLE DRILLING-JIGS AND THEIR USE.

In Figs. 42 and 43 respectively are shown two examples of the duplication of work by drilling by the use of jigs of the simplest possible construction. The work for the drilling of which these jigs were used is also shown, both jigs being used on the same piece of work. Although no great degree of accuracy is required in the location and size of the holes drilled, the use of the jigs saves considerable time and insures the desired degree of interchangeability in the work.

The points drilled in the work by the use of the jig shown in Fig. 42 are four holes at *D D D D*, within *A A*; and, by the jig shown in Fig. 43, a hole through each of the legs *B B*. The construction and use of these two jigs can be clearly understood from the illustrations, as well as the manner of locating and fastening them to the work. As shown, the usual conditions are reversed, the jigs being located and fastened on the work instead of the opposite, which is usually the case. The jig shown in Fig. 42 consists of seven parts. The bushing and locating-plate *C* is of machine steel finished on the ends so as to fit easily into the portion of the work between *A A*. The four holes for the drill-bushings are located and bored and reamed to size, and the four hardened bushings forced in. A hole is then drilled and tapped in the centre of the side *C* to admit the stud *E*. This stud has about one inch of thread on the outer end for the fastening nut *F*, which is finished to the shape shown and the outside heavily knurled. When drilling, the casting, or work, is stood

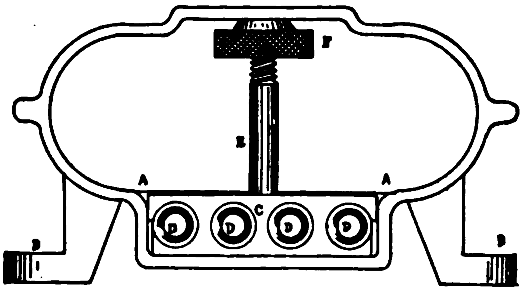


FIG. 42.

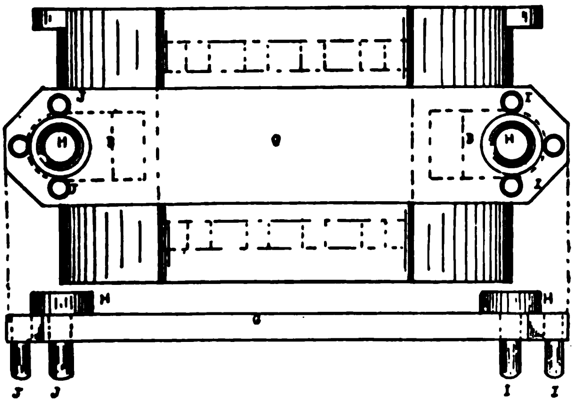


FIG. 43.

up on the drill-press table and the jig located between the points *A*-*A*, as shown, and the nut *F* tightened against the opposite side. The four holes are then drilled through the drill-bushings and the jig removed by simply loosening the nut *F*.

The second jig, shown in position on the work and in a side view in Fig. 43, is of such simple construction that it can be understood from the illustrations. The three pins *I I I* and *J J J* respectively, at either end of the bushing-plate *G*, locate the jig on the legs *B B* of the work, and the two holes are drilled through the bushings *H H*.

TWO DRILLING-JIGS FOR THE SPEED-LATHE.

In Figs. 44, 45, and 46 are shown views of two drill-jigs of rather novel character, suggestive of ways of drilling a large variety of different shaped pieces. Fig. 44 is used for drilling the hole *a* in the brass piece *A* (Fig. 45) used for a basin plug, a rubber washer being afterward fastened around the neck, the *a* hole being for the chain ring.

For this jig a piece of 1-inch round machine steel was turned with a taper-shank to fit the tail-spindle of the speed-lathe, and a hole was drilled through the body at *E*. The piece was then held in a two-jawed chuck, and this hole was enlarged and bored to the shape shown, so that the piece *A* would just fit it.

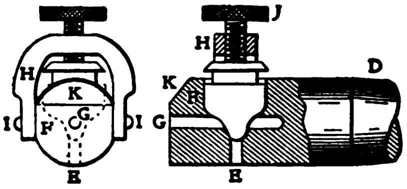


FIG. 44.

The jig was then put in its place in the tail-spindle and the drill-hole *G* was drilled. The swinging yoke *H* was got out by forging a piece of steel, machining it to the shape shown, and fastening by pins *I* to two flat sides milled on the body of the jig; a knurled head-screw *J* secured the work. A portion of the face of the jig was milled away at *K* for clearance for the yoke *H*, to allow it to swing off and on freely.

When in use the jig was set in the tail-spindle and the drill was held by a small chuck in the live spindle. The yoke *H* was swung downward and the work to be drilled was placed in the jig at *F*, as shown. The yoke was then swung up and the fastening screw *J* tightened. The tail-stock was then run out, and the drill entering the hole *G*, the hole *a* was drilled. The hole *E* through the body of the jig allowed an easy escape for the dirt and chips.

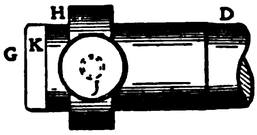


FIG. 45.

In Fig. 46 we have another adaptation of this style of drill-jig, although the construction is somewhat different. It is used for drilling the hole *B B* in the screw-plug *C*. These plugs were brass castings and were finished all over to the shape shown in section. The jig for the holes *B B* consisted of a piece of 1¼-inch round machine steel turned with a taper-shank to fit the tail-stock the same as the other. It was then put into the live spindle and a hole *P* drilled to *R* by using an extra long drill of the diameter required. The front of the hole *P* was nicely rounded with a hand tool to allow an easy entrance for the drill when the jig was in use. The jig was transferred to the milling-machine and a section was milled away at *M M* to the depth shown, so that the centre of the flange of the work *C*, when in position, would be in line with the drill-hole *P*. A machine-steel disk *N* was finished in diameter to fit the hole in the work *C*. A hole was let through the centre of this disk, and it was fastened by the screw *O* on the flat milled surface of the jig, central and in line with the drill-hole *P*. The spring-pin *Q* was made with a spiral spring *R* at the back and a handle at *S*, a clearance-channel *T* being cut in, thus allowing the pin *Q* to be pulled back and the work released. When in use the work *C* was located on the jig by the disk *N*. The tail-spindle was run out and the first hole *B* in the flange was drilled to the depth required. The work was then turned around the disk *N* until the hole drilled in the flange was opposite the locating-pin *Q*, which snapped into it by the tension of the spring *R*. The second hole in the flange was then drilled.

The two jigs here shown for use in the speed-lathe are about the least expensive that could be devised for the drilling of the work shown, and it was surprising the amount of work that could be turned out with them. Jigs of this design and construction are very popular in the brass shops, where the speed-lathe is often adopted for work that is ordinarily done in drill-presses.

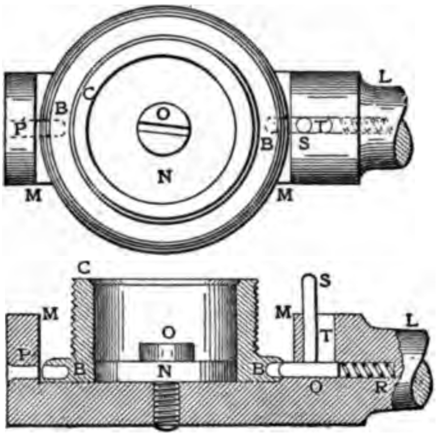


FIG. 46.

A DRILL-JIG FOR ACETYLENE GAS BURNERS.

The work to be drilled was a solid casting of composition of the shape shown in Fig. 47, which had been dropped in a forming-die under the drop-hammer and then run through a trimming-die to have each of the same shape and size. After the hole *R*, Fig. 47, had been drilled and tapped in the monitor, the piece was ready for the jig. This is shown from the side and front in Figs. 48 and 49. *O N P* and *Q*, Fig. 47, are the holes to be drilled in the burner. *O* and *N* were drilled to No. 17, and *P* and *Q* to No. 40 drill-gauge size. The small holes were afterward soldered at the top, thereby leaving two clear passages for the gas.

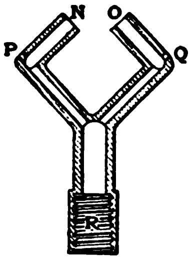


FIG. 47.

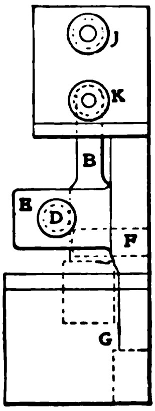


FIG. 48.

The jig itself was a casting, flat at the back, with three projections—one at the top to hold the bushings, and two, *L* and *M*, at the base; also the two lugs *L L*. In the first place, a piece of $\frac{5}{16}$-inch thick flat machine steel was planed square to fit the inside of the burner and act as a gauge-plate to locate and hold it. It was then fastened with the central screw and the two dowel-pins *F F*, which were two Stub steel pins filed on the

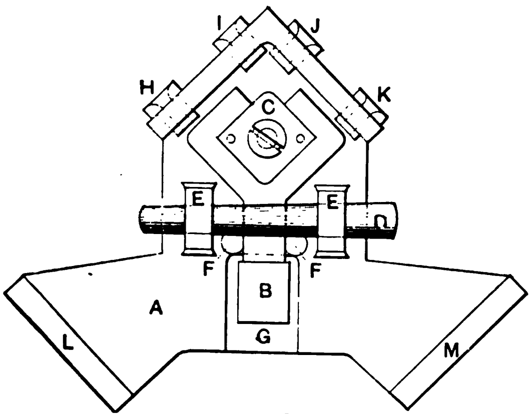


FIG. 49.

inside of each so that the burner would drop freely, but without play, between them. Next a taper hole was drilled through the two lugs *E E* and the lock-pin *D* fitted in, with the side bearing on the work flat. The work *B* was then put in place and the lock-pin *D* driven in, thereby holding the work fast and snug. The bushings *H I J* and *K* were then made, hardened, and lapped to size. The holes for the bushings were then laid out, drilled and reamed to size, and the bushings driven in. The drilling was done in a two-spindle drill. First, the jig was stood up on the base *M* and the holes *O* and *P* drilled, then on the base *L* and the holes *N* and *Q* drilled; then, taking out the lock-pin *D*, the work was easily removed. The jig worked very satisfactorily, each boy drilling from 250 to 1,050 a day. The casting was sunk in at *G* to give clearance to the work at *B*.

DRILLING-JIGS FOR ODD-SHAPED CASTINGS.

The two jigs shown in two views each, in Figs. 50, 51, and 52 respectively, were used for the rapid drilling of the holes in the castings Figs. 53 and 54, and, as they proved rapid and accurate producers, the design and construction of them may prove of interest to those having a number of holes to drill in odd-shaped castings.

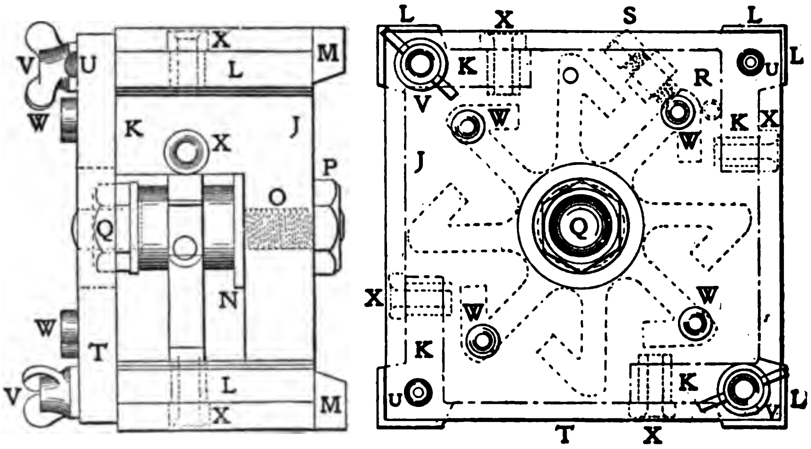


FIG. 50.

The first jig, Fig. 50, for drilling the casting Fig. 53, is a very simple and inexpensive type, so constructed as to allow of the rapid locating and fastening of the work and the removal of the same when finished. The casting as drilled is shown in two views in Fig. 53, and has two holes *A B* drilled in each of the eight arms. Before being drilled the castings are chucked in the turret-lathe, and the centre hole *C* is bored and reamed to size, and the hubs are faced.

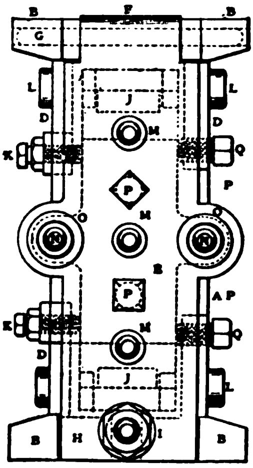


FIG. 51.

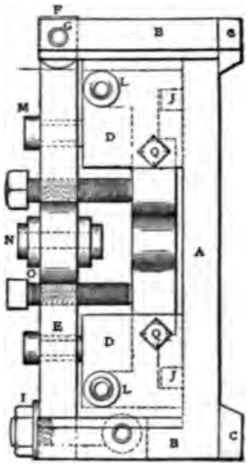


FIG. 52.

The jig Fig. 50 consists of two castings, of which *J* is the body casting and *T* the lid. There were openings at all sides for the escape of the dirt and drillings. The legs *L* on four sides and those at *M M* on back are finished and scraped, so as to be dead square with each other. The face of the body casting is also squared with the sides, so that the lid will rest squarely on it. Two dowel-pins *U U* locate the lid, and the thumb-nuts *V V* are for fastening it. A stud of tool steel, which is threaded at both ends and its largest diameter finished to fit snugly the centre hole *C*, is let into the bottom of the body casting, as shown at *O*, and held rigidly in position by a nut *P* at the back. A large hole is bored in the centre of the lid, so as to clear the nut *Q*. The sideway locating-point is at *R*. It consists of a Stub steel pin, which is hardened and driven into the body of the jig. The set-screw *S* is also hardened and let in through the projecting lug, and is used for forcing the work against the locating-pin *R*.

The four bushings *X* are let in as shown, and the manner of locating and finishing the holes was as follows: The body casting was strapped to the table of the universal milling-machine, and the centre of each hole was located, and the hole was finished in turn by the use of a Brown & Sharpe height-gauge for locating, measuring from one side of the jig and from the miller-table, and using a sharp end, mill for finishing, first drilling the hole with a drill about $\frac{3}{32}$-inch under size.

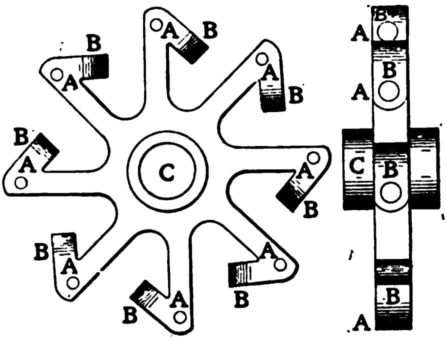


FIG. 53.

The four holes for the bushing *W* were located by the "button method," as described in Chapter III. After being located, the four holes were drilled and finished to size by strapping the lid on the lathe face-plate and locating each button to run true by the use of an indicator.

When using the jig, the lid *T* was removed by unscrewing the thumb-nuts *V*, and the casting to be drilled was located on the centering-stud *O*, the faced hub of the work resting squarely on the finished boss *N*. One of the angular-faced projections of the work is then forced against the locating-pin *R* by tightening the set-screw *S*. The nut *Q* is then fastened securely within the jig, as shown by the dotted lines in the plan view of the jig. The holes *B* in the projections are then drilled through the bushings *X*, that is, through every other one of the projections, by standing the jig on each of the four pairs of legs *L* in turn. The jig is then rested on the legs *M* and four of the holes *A* are drilled through the bushings *W*. The lid of the jig is then removed, and the nut *W* and the set-screw *S* loosened. The work is then moved and located so that the holes *A* and *B* in each of the four remaining projections may be drilled. The operations of locating and fastening the work and then of drilling the holes are repeated.

As can easily be seen, the design and construction of this jig is of the simplest possible character consistent with accurate and rapid production. Although it is necessary to locate the casting twice, the time entailed amounts to very little, and is fully compensated for when the simplicity and cheapness of the jig are considered, as in order to drill all the holes in one operation a far more complicated jig would have been necessary.

In Figs. 51–52 are shown views of a jig of a rather more elaboate and complicated design than the first. It is used for drilling the holes in the casting Fig. 53, and finishing the hubs—that is, the three holes *G* and the hole through each of the lugs *F*, the hole through the hubs at *I* and the finishing of the hub at *H*. As shown in the two views of the jig, the work is located at three points at each of the finished projections or lugs *J*, locating within the parts *D*, which are drilled to size in a preceding operation. The work is located sidewise against the two adjustable stops *K*, by tightening the two set-screws *Q* against the work. The lid *E* of the jig is hinged within the body casting at *F* by the pin *G*. Legs are cast on two sides and on the bottom of the body casting, as shown at *B* and *C* respectively. The four

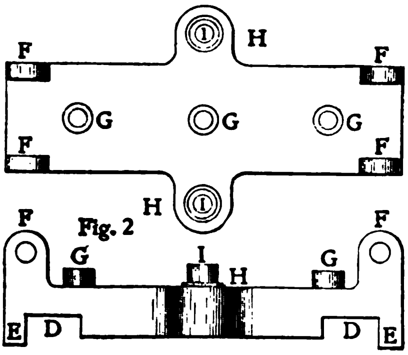


FIG. 54.

bushings *L* are for drilling the holes through the lugs *F*, and those at *M*, in the lid, for drilling the three holes *G*. The method used for fastening the lid while the work is being drilled is by means of a swinging-stud and a nut and washer *I*, the stud being hinged to swing free in the body casting at *H*, a slot being let in it and in the lid for that purpose. Two set-screws *P* are let into the lid for locating and fastening the work within the jig.

The two large bushings *O*, for use when finishing the hubs, are permanently located within the lid, while those for drilling the hole *I* in the hubs are inserted within them when in use. When using the jig the work is located and fastened within by the set-screws *Q* and *P*, and all the holes are then drilled. The two bushings *N* are then removed, and the hubs are faced and reduced to size. The fastening set-screws are then released, the swinging-stud *I* is thrown back, and the lid raised, after which the work is removed.

All the various parts of both these jigs, including the castings, are made sufficiently heavy and strong to withstand all strain to which they may be subjected when in use. The manner of locating the work is such as to be positive, and without the possibility of shifting during the operation of the tools. The means and points chosen for the fastening of the work within the jigs are such as to be rapid to manipulate, and in no way to interfere with the drilling; and, lastly, the design and construction of both jigs are such as to dispense with all unnecessary parts and labor.

JIG FOR DRILLING ROUGH CASTINGS IN PAIRS.

Fig. 56 shows two views of a drill-jig, with work in position for drilling holes in the tops of rough pairs of bracket castings. These castings were used in large numbers and were of the shape shown in Fig. 55. The three holes in the body portion were cored, and, as the pairs were not machined at any point before drilling, the holes were used as locating-points in the jig. The jig consists of a body casting in the shape of an inverted "T," *X* being the base and *G* the upright which supports the plate *E* and the work. The work is located in pairs on either side of the upright by the dowel-pins *D D D*, which enter the cored holes and are held by the clamping device, a cross-section of which is shown in Fig. 57. This clamp is of tool steel, with wings at *I*

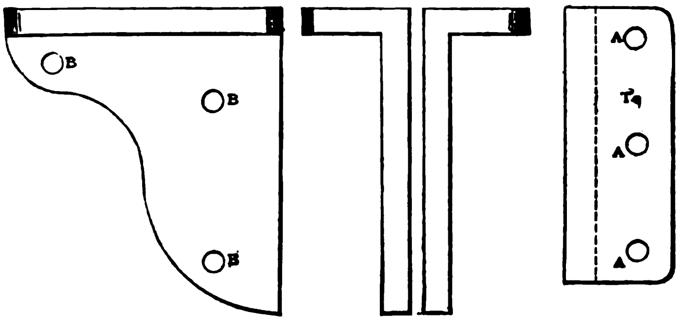


FIG. 55.

and *J* to swing over and clamp the work, the centre portion *L* being turned to fit the semi-circular bottom of the slot in the upright *G*. A plate *H* is let into and fastened to the front of the upright *G* by the two screws *N N*. This plate has a stud *M* fastened in the centre of it, in line with the circular portion *L* of the swivel-clamp. The face of the stud is finished to the same radius as the portion *L* and is of a length sufficient to allow of the face acting as a back bearing for the swivel-clamp to swing on.

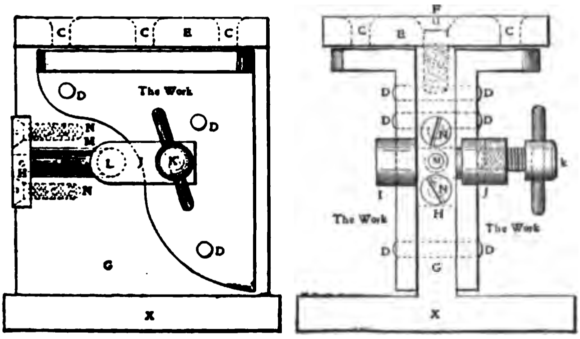


FIG. 56.

This construction allowed of making the clamp in one piece, and gave better results than if one of the wings had been made separate. About $\frac{3}{32}$ clearance was given lengthwise to the circular portion *L* for rapid fastening and releasing when in operation. The plate *E* serves as bushing-plate and bushings as well. It is of tool steel, with three holes at each side as guides when drilling the holes *A A A*. The holes *C C C* are countersunk to allow a ready entrance for the drill. The plate is hardened and drawn slightly, after which it is ground on both sides and the holes lapped. The plate is located on the body casting by two flat-head screws *F* and two dowel-pins not shown.

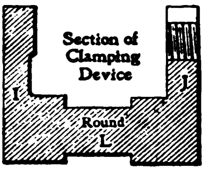


FIG. 57.

When the jig is in use the clamping device is swung out of the way and a pair of castings are located on the jig, dowel-pins *D D D* being made an easy fit in the cored holes. The swivel-clamp is then swung back and the screw *K* is tightened against the castings, thus fastening the work against the sides of the upright *G*. The six holes are then drilled. This jig allows of the drilling being accomplished to the required degree of accuracy and interchangeability and in a very rapid manner. The swivel-clamp, for fastening the casting against the rib sides, can be adopted to advantage for locating and fastening work of a variety of different shapes, whether the parts are sent to the jig rough or are first machined at different points.

JIG FOR DRILLING AND COUNTERSINKING.

The jig shown in Figs. 59–60 was used for drilling and countersinking the holes *D* in the casting Fig. 58. The castings before being drilled are bored at *A* to a diameter of 1¼ inches, and the hub is faced at *b b*. The hole *D* is required to be central with the rib *C*. The parts comprised in the jig are: the body casting, with the circular portion at *E*, a base at *P*, and two feet at *R R*; the bushing *R G* and the locating and fastening device *J I L K* and *N*. The portion *E* is bored at the front slightly larger than the hub of the work, and is faced at the back for the nut *N*. The bushing *G* is hardened and ground and forced into the top. It is lapped to fit a combination drill and countersink. The locating and fastening device consists of a machine-steel stud with the nut *N*, and is turned at *K* to fit a reamed hole at *E*, and at *F* to fit the bored hole in the casting.

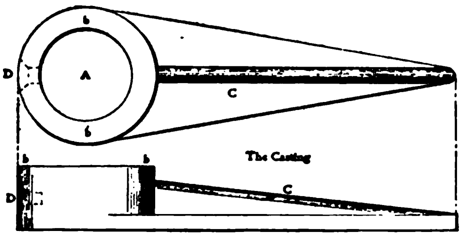


Fig. 58.

A half-round groove is let in at *L* as clearance for the drill. A large head at *J* and a washer *I* with a section cut out at *M M* complete it. The work is located on the jig, so that the hole when drilled will be central with the rib *C* by entering the rib into the slot at *O*. A slot is let in at *Q* in the base as clearance for the end of the work.

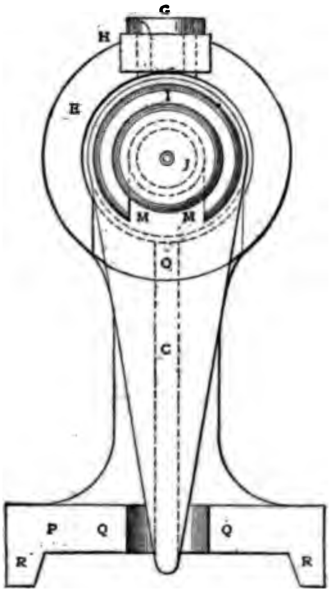


Fig. 59.

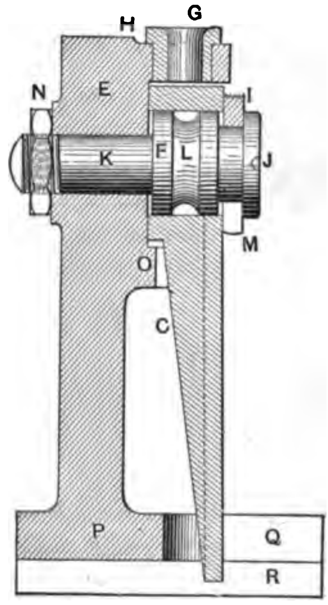


Fig. 60

When in use the washer *I* is slipped off the locating-stud and a casting is located. The washer is then slipped over the neck of the stud and the nut *N* tightened. The hole *D* in the work is next drilled and countersunk. To remove the work all that is required is to loosen the nut *N* and slip off the washer.

A JIG FOR DRILLING CAMS.

The cams to be drilled, Fig. 61, were of brass, $\frac{9}{32}$-inch thick, cut from a bar of 1-inch round stock, the cutting off being done in the monitor. They were to be drilled eccentrically, as shown, with a $\frac{11}{16}$-inch drill. Of course, to drill a hole of this size in pieces so small and have all approximately alike necessitated a jig that would hold them correctly and securely. The jig is shown in Fig. 62, with a top and an end view, the top view with the plate for holding the bushing off. Fig. 63 shows plate and bushing.

A casting was used for the jig proper, with two wings as shown, so that it could be set true and strapped on the drill-table. The bushing-plate was planed on the top and bottom and fastened with four flat-head screws *J* and two dowel-pins *K*. A bushing *L*, of tool-steel, with an $\frac{11}{16}$-inch hole, was then made, hardened, ground, and lapped. The casting, with the plate in position, was then set on the face-plate of the lathe, and a hole $\frac{11}{16}$-inch in diameter bored straight through at *E*. The hole in the plate was then bored out so that the bushing would just drive in. The plate was then removed without disturbing the casting, and a piece of turned steel $\frac{11}{16}$-inch in diameter, with a prickpunch mark exactly $\frac{1}{8}$-inch from the centre, driven into the hole *E* in the casting tight enough to keep it from turning. The casting was then moved sidewise on the face-plate until the prickpunch ran true. The piece of steel was then removed and the hole *E* rebored to 1 inch in diameter and $\frac{9}{32}$-inch full, deep; that is, so that the work, Fig. 61, would enter freely. The casting was then removed from the lathe and a slot planed in the way shown at *N*, Fig. 62; that is, $1\frac{1}{8}$ inches wide at the front and running into the

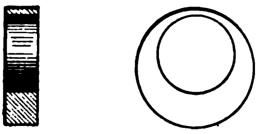


FIG. 61.

hole *B* as shown. A piece of steel, *C*, $\frac{9}{32}$-inch thick, worked out in the way shown to keep the work from being bruised, was then made. A $\frac{5}{16}$-inch taper hole was drilled in *A* to admit the lock-pin *D*, which was of Stub steel, with one flat side facing the work. The lock-pin and the piece *C* were both hardened. *G* is a bracket of sheet steel cut out and bent in the way shown and held by screws *I I*; *F* is the knock-out pin, *H* the spiral spring, and this completed the jig. The plate, Fig. 63, was screwed on and the jig strapped to the drill-table. The work, Fig. 61, was dropped in place, also the piece *C*, and the lock-pin *D* was given a tap, which held the work fast. The hole was drilled, the lock-pin removed, and the knock-out hit sharply

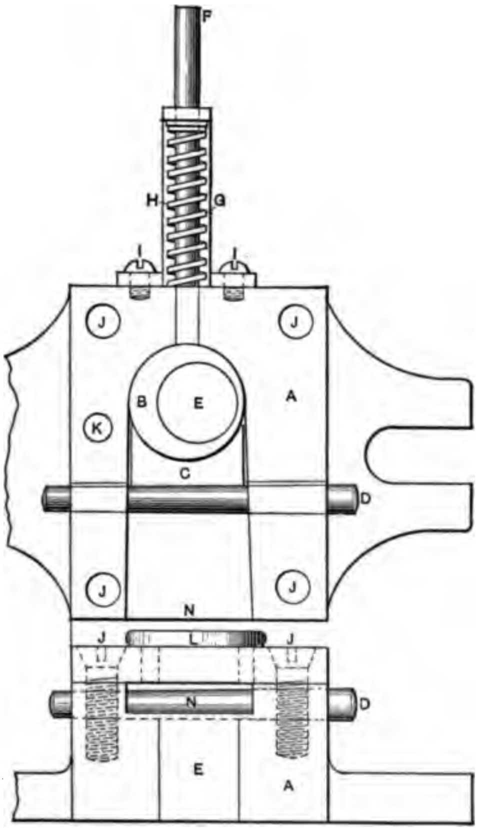


FIG. 62.

with a hammer, causing the work and piece *E* to come out without any trouble, the spring *H* bringing the knock-out back in position.

One thing necessary was to have the hole *E* in the casting and the hole in the bushing exactly the same size as the drill; also the drill ground central, thereby leaving only a very slight burr, as, had it been otherwise, it would have caused trouble in removing the work.

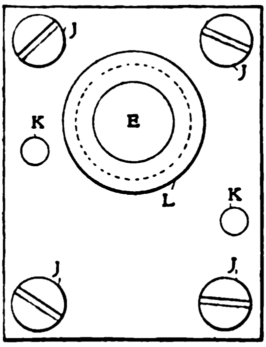


FIG. 63.

The jigs illustrated and described in this chapter should prove suggestive for the devising of means for the rapid and accurate production of different shaped repetition parts which are to be drilled. One thing which should always be kept in mind when designing or constructing fixtures for interchangeable production is this: the fixtures used for rough or simple shaped castings should, if anything, produce quicker and cheaper than those for machined or perfectly interchangeable ones, because castings of the first type are, as a rule, sold at such a low cost that unless they are produced very rapidly no profit is possible.

CHAPTER V.

Intricate and Positive Drilling-Jigs.

As we are now about to take up descriptions of a class of drilling-jigs in which the utmost accuracy and interchangeability in the product are essential, I wish to impress upon the mind of the reader the necessity of making himself familiar with the fundamental principles and the most accurate and practicable means for accomplishing accurate results in the finishing of the various parts of such jigs. For this reason I call his attention again to Chapter III., in which is contained all that will help the mechanic to devise and construct accurate drilling-jigs successfully.

JIG FOR DRILLING A MULTIPLE-CAM BODY.

In Fig. 64 is shown a casting with two circles of holes drilled in face at *A* and *B* in the relative positions shown in the projecting lugs. As this casting, when finished, formed a part of an attachment for an embroidery sewing-machine, and acted as a multiple cam, the accuracy of the holes had to be positive. The jig used for drilling them is shown in two views in Figs. 65 and 66, and as the design and construction are clearly shown, very little description is necessary. We will confine ourselves, therefore, to the accurate locating and drilling of the work. *D*, Fig. 65, is the body casting, finished on all sides, as shown, the lid *L* being hinged on one end, at *M*. It is then swung on the lathe face-plate and a hole is bored through both, at *Q* and *E* respectively. The hole *E* is to admit the indexing-plate stem *G*, and

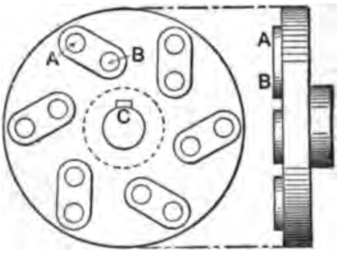


FIG. 64.

the hole in the lid is for clearance for the clamping-stud *U* and also as a general point for finishing the bushing-holes. The index-plate is a forging; the plate *F* is of tool steel, and the stems *H* and *G* of mild steel. The stem *H* is finished to fit snugly the centre hole in the casting Fig. 64, and is tapped for the clamping-stud *U*. The stem *G* fits the hole in the base at *E*, and is shouldered and threaded for the washer *I* and nut *J*. The plate proper *F* is indexed to six and is hardened; then it is ground and the notches lapped to a gauge, so that the divisions are spaced to the utmost accuracy. As a positive locator for the work the best point is the keyway at *C*, Fig. 64; but before letting in the key in the stem *H* of the index-plate, Fig. 65, the bushing-holes in the lid *L* are finished.

For this operation an arbor is turned up—one end tapering to fit the driving-head of the universal milling-machine, and the other a driving fit within the hole *Q* in the lid. The lid is then forced onto it and the arbor driven into the head, which is set on the extension plate facing the spindle. A small centre drill is first used and the table set to allow of centring the holes on the

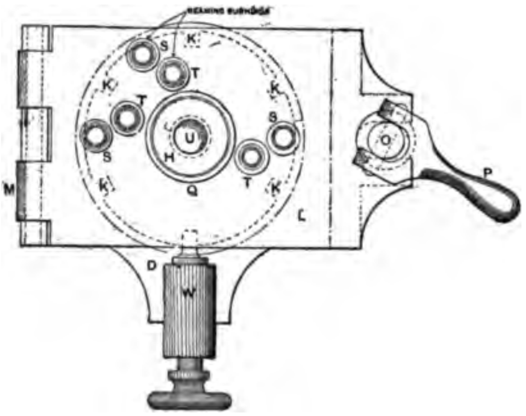


FIG. 65.

proper radius. Three holes, *T*, Fig. 65, are now drilled, and then finished to size by butt-mill with a sharp end cut. The three outside holes *S* are finished in the same way, and located in the proper relation to the first circle by using a standard plug, entering it into one of the holes *T* and then using the verniers to get the exact distance from it to the side of the end-mill. When the bushings are finished and driven into the holes, one of the castings is clamped into the jig, and the index-pin *W* let into the base of the jig at *D* is let into one of the index notches.

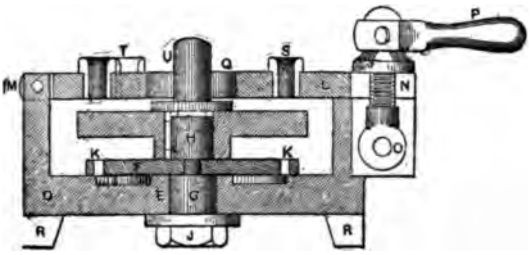


FIG. 66.

The casting is then adjusted until the holes when drilled come in the position shown in Fig. 64. The keyway is next located in the stem *H* and the casting removed. After the key is let in the jig is complete.

In using this jig the work is clamped in position, as shown, and the holes drilled through the bushings *S T S T*, which are directly opposite one another. The index-plate is then moved one space; the first two holes drilled are reamed through the two extra bushings *T* and *S*, and four more holes are drilled through the other bushings, as before. The principle of this jig can be used to the best advantage for work in which holes are to be drilled around an exact radius.

DRILLING- AND HUB-FACING JIG.

Figs. 68 and 69 show two views of jig for drilling the holes *F F F* and *E* and facing the hub *D* of the casting, Fig. 67. It is very rapid in handling work, as well as accurate in production. It can be adopted for finishing work in which rapidity in drilling is the object sought, as one lever locks and positively locates the work in position. Before being drilled the casting, Fig. 67, is machined on the back *A*, the sides *C C*, and the channel *B*, thus allowing of positively locating it. The jig consists of one casting, shown at *G G G*, which strengthens it for the locking-cam

K. The work is located on the two spots *H H* on the bottom, and on the sides on the adjustable screws *J J*, while endwise the flat piece *I* locates it by the channel. The three bushings *P P P* are let in by the "button" method described in Chapter III, as is also the hole for the facing-bushing *N*, while the bushing for the hole *E*, Fig. 67, is ground to fit the inside of bushing *H*.

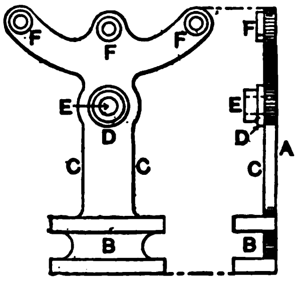


FIG. 67.

The clamping- and locating-cam *K M* and *L* is made so that the portion *K* will press down the work on the spots *H H* and carry it against the plate *I*; while the portion *L* is finished to a slight pitch on the inner face—as shown at *S*, Fig. 70—which forces it against the screws *J J*. When in use the work is clamped within the jig, as in Fig. 68, by pulling down on the lever *M* of the locking-cam. The bushing *O* is then removed and the hub *D*, Fig. 67, is faced. The bushing *D* is next inserted, and the hole *E* and also the three others are drilled

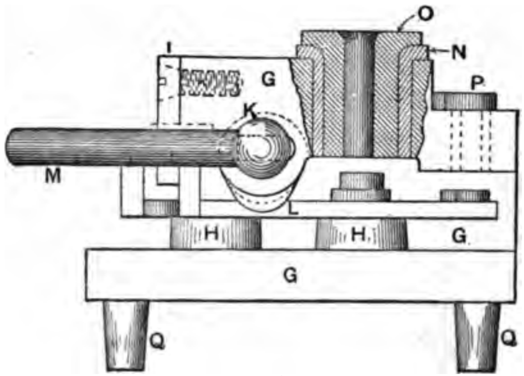


FIG. 68.

through the bushings *P P P.* The locking-cam is thrown back and the work removed and another piece inserted.

The locating and fastening of work within jigs by the cam-lock here described is one of the most rapid and reliable means for accomplishing it, and can be adopted for the drilling of a large number of different-shaped castings where two or more portions have been machined, so as to get the work at the locating-points to a uniform size.

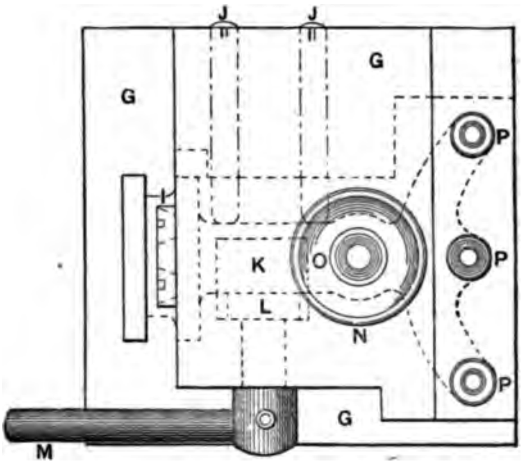


Fig. 69.

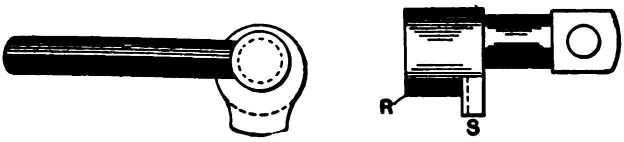


Fig. 70.

AN INTRICATE JIG FOR TYPEWRITER BASES.

As a practical illustration of an intricate jig and the locating and finishing of a large number of holes to the maximum of accuracy, the jig illustrated in three views in Figs. 72, 73, and 74 will serve as an example. It is used for drilling all the holes—to the number of fifty-six—in the casting Fig. 71. The casting when finished forms the base of a typewriter and must be absolutely interchangeable.

In work of this kind care should be taken to have all the castings of uniform size and shape. To accomplish this the pattern should be perfect and, in all cases of metal, finished at all points to the size required—allowing, of course, for shrinkage and surplus stock at all the points to be machined. When perfect patterns are made there is no doubt of the result in the castings. The casting, Fig. 71, is first faced on all projecting lugs and surfaces, to gauge, on a profiling fixture. The design and construction of the jig are clearly indicated in the three views, and the finishing of all parts in any way similar to those used on the other jigs is accomplished in the same way. The points of sufficient interest to describe in detail are the manner of locating the work, the finishing of the bushing-holes and the clamping devices.

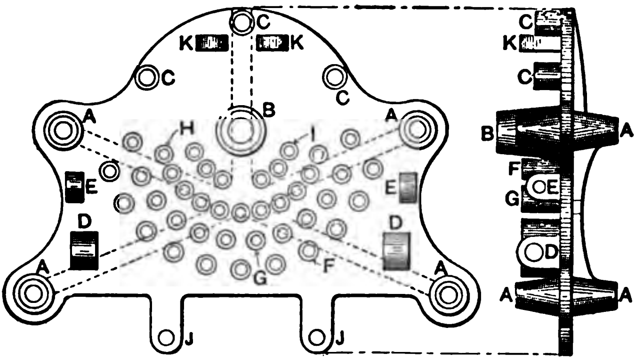


FIG. 71.

The casting rests within the jig on the four legs *A A A A*, Fig. 71. It is located endwise against the two points *Y Y*, Fig. 72 (these points being milled to the radius of the ends of the casting which locates in them), and sidewise by two adjustable set-screws *B B*. The clamping devices are all located on the lid *M* and consist of the three knurled head-screws *A A A*, Fig. 72, and of the cam-locks *Z Z*. These locks, shown clearly in Fig. 75, consist of an eccentric turned stud and a square nut, both of which are hardened and located on the jig as shown. By giving them a half turn they force the work against the locating-points

Y Y and also against the set-screws *B B*, and lock securely in position. The lid is located on the body of the jig by the three dowel-pins *N N N*, and clamped by the two swinging-clamps *O O* and the large knurled nut *P*. This manner of fastening contributes to the rapid locating and removal of the lid. The legs are on three sides of the jig and on the bottom. They are of tool steel, hardened and lapped in the way before described. In finishing these legs a number of tool-makers mill a square at the top—rather an elaborate way; all that is necessary is to mill a

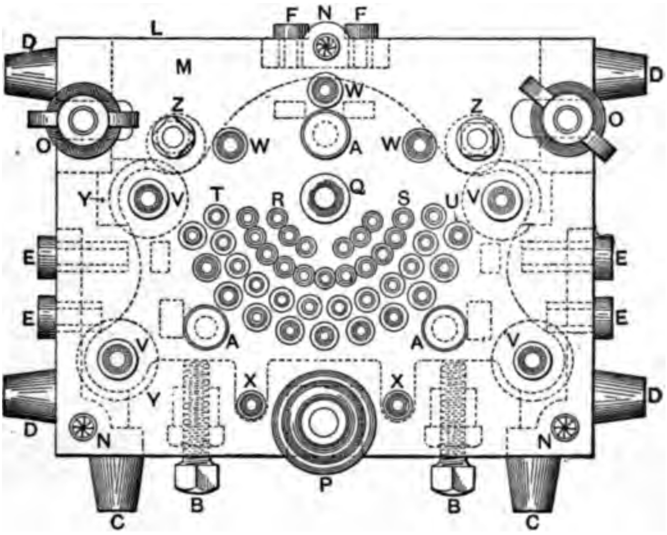


FIG. 72.

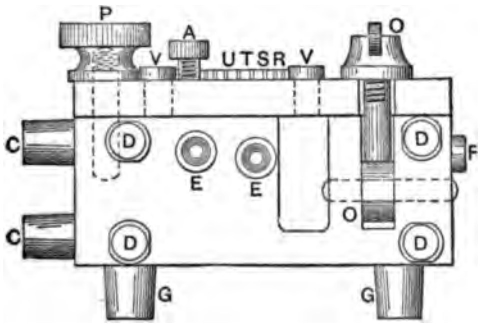


FIG. 73.

slight flat on two sides, which answers all the requirements and is far more expedient.

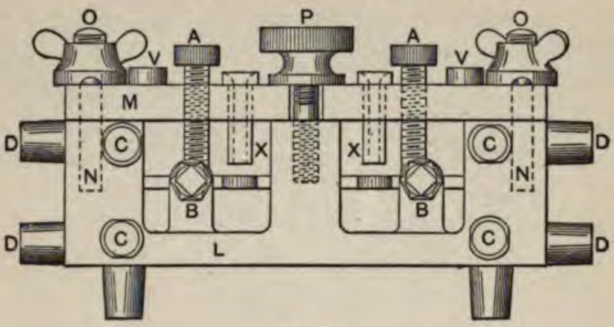


FIG. 74.

The most difficult part of the construction is the finishing of the bushing-holes. By reverting to Fig. 72 it will be seen that there are four sets of holes, at *R S T* and *U*, each set on a radius central with the centre hole *Q*. The first hole is that for the bushing *Q*, which is finished on the lathe face-plate by the "button" method. This hole is bored to a size really larger than necessary, so as to admit an arbor which is located in the dividing head of the miller. This being done with the head facing the spindle, the first set of holes *R* are centred and finished in the position shown by setting the table and head so that the centre drill is on the proper radius with centre hole *Q*, and then indexing for sixteen, finishing six holes *R* and skipping the centre one. The next row *S* and the rows *T* and *U* are finished in the same way by lowering the table until the centre drill is on the radius required, and then indexing for twenty-five and finishing eleven holes on the arc as shown. The lid is then removed and the four holes *V V V V* located with buttons, inserting a standard plug in the holes *Q* and getting the distances from it and the side of the jig with a height-gauge, finally finishing the holes in the lathe. The holes *W W W* and *X X*, and also those in the side of the jig at *E E E E* and *F F*, all go through the same operation. The manner of locating and clamping the work in position and then drilling all the holes is clearly shown

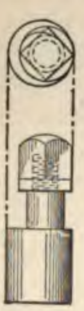


FIG. 75.

in the three views of the jig and requires no further description.

The design and construction of the three separate and distinct types of jigs shown and described in the foregoing comprise the best principles for the positive locating, fastening, and rapid handling of work of the class shown, while the method described for finishing the bushing-holes is the most accurate that has yet been devised for accomplishing this part of the work. If followed out as defined, the results obtained will be satisfactory to all concerned.

TWO DRILLING-JIGS FOR SMALL, ACCURATE WORK.

In Fig. 77 is shown a drilling-jig embodying a number of practical ideas. This jig is for spacing off and centring holes or punch-seats in small wheels, which are in turn used when supplied with punches for perforating leather shoe tips, and miscellaneous service of that character. The wheel before drilling is shown in a cross-section at *W*, Fig. 76; and as finished, with all holes drilled and counterbored and the punches inserted, at *H*, Figs. 79 and 80, in which is shown the machine on which the wheels are used. These wheels are of cold-rolled machine steel and are finished all over in the turret-lathe.

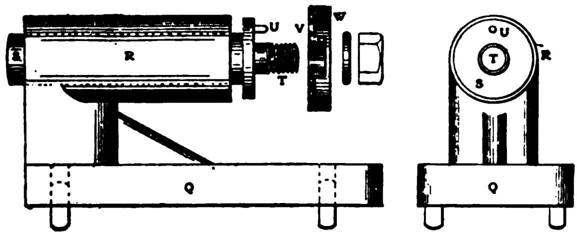


FIG. 76.

As the holes or seats for the perforating punches are usually very small, it is not possible to drill them to the required degree of accuracy in one jig; so two jigs were used—one for spacing, locating, and countering the holes, and the other for drilling and counterboring them. The jig for spacing and centring the holes is shown in Fig. 77, and the jig for drilling and counterboring in Fig. 76.

The spacing and centring jig, Fig. 77, consists of a flat-bottomed casting *A* with two standards *B B* which support the indexing device. There is a shaft *C* with a wide shoulder at the front end to rest against the face of the standard, and an end projecting from this shoulder to fit the hole in the wheel and threaded for the nut *F*. A small pin in the face of the shoulder locates the wheel in position on the spindle. The index-plate *G* has three circles of holes, the number of the holes being designed for handling as large a variety of wheels as possible. The index-pin *J* is located in a swinging arm *H*, which swings on a stud let into a corner of the back standard *B*. A flat spring *K* is fastened to the arm with the end resting in a notch in the index-pin. Instead of using bushings to guide the drills, a piece of $\frac{5}{16}$-inch Stub steel is used, it being finished with a flat at *L* with three holes for the drills. This end is hardened and the opposite end *M* is threaded for the adjusting-nut *O* located in the fork of the bracket *N*. This adjustment allows of marking different combinations of holes in wheels of different thicknesses by the use of the one drill guide.

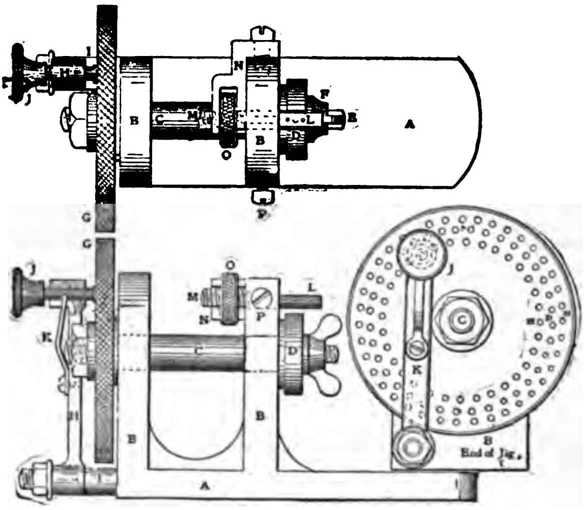


FIG. 77.

In conjunction with this drill-jig a small sensative drill is used, and as the design and construction are clearly shown a detailed description is unnecessary. The manner of using the jig, Fig. 77, is as follows: A wheel *D* is located on the spindle as shown, a drill is fastened within the chuck of the press, and the table *A A* of the press is set so that it can be raised just high enough to centre or spot the holes. The index-pin *J* is then set for the required circle of holes by swinging and locating the arms *H*. After centring the first hole the next is located and centred by pulling out the index-pin *J* with the left hand and rotating index-plate *G* with the right, the outside of the plate being knurled to facilitate it.

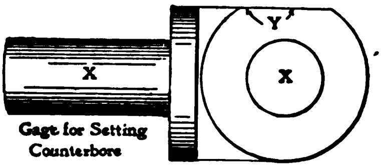


FIG. 78.

The jig for drilling and counterboring the wheels is shown in Fig. 76. It consists of a casting *Q* with a floating spindle *S* on which the wheels are placed to be drilled. This spindle is finished on the front end the same as the one used in the first jig,

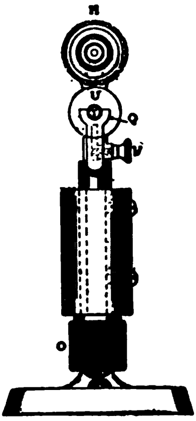


FIG. 79.

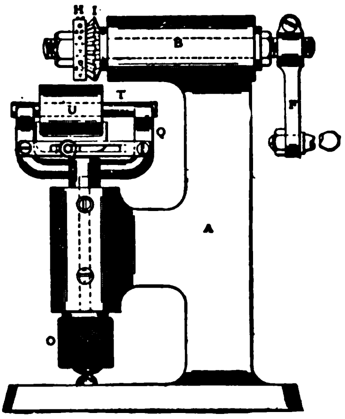


FIG. 80.

the work being located and fastened upon it in the same manner, the locating-pin *U* entering the hole *V* in the wheel *W*. Two dowel-pins are let into extreme corners of the bottom of the jig to coincide with two holes drilled in the table of the drill-press, so located that the spindle *S* will be in line with the centre of the drill-chuck. By this means the holes can be drilled very rapidly and with the certainty that they will all point toward the common centre. When drilling the wheels, the spindle is rotated until one of the spotted centres is in line with the drill. The work is then pressed upward against it and the drill instantly locates it perfectly in line.

The counterboring of the holes is accomplished in the same manner as the drilling; the counterbore being set to the required depth in the holes by means of the groove *X*, the table of the press being raised until the face of the counterbore rests on the flat face *Y* of the gauge, which is slipped into the spindle holes of the jig. The table is then set, the gauge is removed, the work-spindle *S* is reinserted and the holes in the wheel are finished to the diameter and depth required.

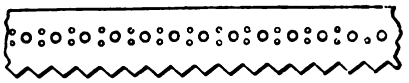


FIG. 81.

The manner in which the wheels are used when finished is shown in Figs. 79 and 80. *H* is the wheel with the punches inserted; *I* is the pinking-cutter for pinking the edge of the work; *A* the body of the machine; *B* the cutter and disk spindle, which is rotated by hand by the crank handle *F*; *V* a hard-rubber holder which runs free and can be adjusted on the yoke spindle *T* and raised or lowered by the knurled nut *O*. A sample of the work produced is shown in Fig. 81.

JIG FOR DRILLING AN ALUMINUM-BASE CASTING.

Fig. 82 shows a base or stand of an electrical cloth-cutter, a casting of aluminum, 7½-inches long. There were eleven holes to be drilled around the outside. These were for 6-32 screws, and were to hold in place a sheet-steel shoe the size of the outside of the casting and the inside shown by the dotted line. There were also six holes drilled in the depressed part *D* which

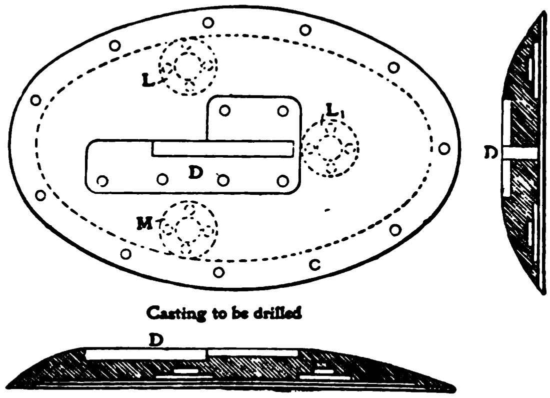


FIG. 82.

were for 10-24 tap, and were to hold the standard that supported the cutter. Then there were three large holes 1½ inches in diameter by ⅛-inch deep, with a ½-inch hole in the centre, ½-inch

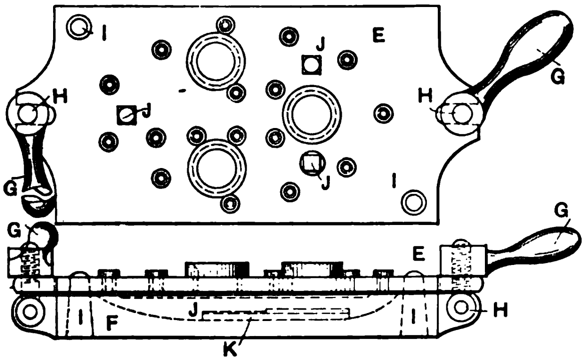


FIG. 83.

deep. There were also four holes drilled within each of these large ones, for 4-40 screws. These holes were for plates which held rollers for the machine to travel on.

The jigs used for drilling these holes are shown in Figs. 83 and 85 respectively; in all there were thirty-five holes, of which twenty-three were drilled in the jig shown in Fig. 83. As will be seen, the jig is composed of two main parts, the top and bottom. The bottom was a casting, for which a special pattern had been made, hollowed out on the inside to allow the work *J* to be set in, with clearance all around. There were lugs cast in each end to accommodate the swinging studs *H H*. After it had been planed flat on the bottom it was milled flat on the inside, and the gauge-plate *K* made and fastened with screws and dowels. This plate was for locating the work, which had previously been milled out at that point to templet, as seen at *D*, Fig. 82. The top plate was then got out of cast-iron, planed on both sides and slotted on the ends for the lock-pins. The two were then strapped together, and the holes for the two dowel-pins *I I* were drilled and reamed. The pins were made and driven into the bottom piece *F;* then using the centre of the gauge-plate *K* for a common centre, all the holes shown were carefully located by the button method, and then trued and bored in the lathe.

Three holes were drilled in the position shown for the set-screws *J J J*. Next, the bushings were all made, hardened, ground and lapped to size, and driven home. The lock-studs *H H* were made of machine steel and the nuts or handles *G G*, also of machine steel, got out and put together, and the jig was complete. When using, the handles *G G* were given a turn so as to allow of their being swung clear of the plate *E*, which was then removed and the work inserted within the plate *F*, locating itself on the gauge-plate *K*. The plate *E* was then replaced, the lock-nuts *G G* swung back and tightened, and the three set-screws *J J J* also tightened. When all the small holes were drilled, the large holes were drilled and counterbored by the combination drill and counterbore shown in Fig. 84. *N* is a flat drill inserted within the counterbore; L a screw for adjusting it, and *M* a screw for holding it.

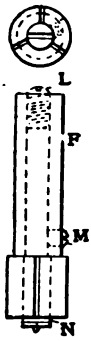


FIG. 84.

This is the style of jig best adapted for this class of work. As will be seen, the work itself is of a shape hard to hold, and the way shown answered all requirements and could be relied upon to machine work that would interchange.

Fig. 85 shows the jig for drilling the small holes within the large ones, for the roller-plate screws; this itself needs little description to be understood. As will be seen, it was composed of a flat piece of cold-rolled steel worked into the shape shown, and two disks turned up to just the size of the large holes in the base. They were then fastened one in each end, so as to interchange in the large holes. The holes for the bushings were then laid out, drilled, and reamed; the bushings made, hardened, and inserted, and it was all ready. The jig was placed so that the disks rested in two of the holes *L L*. The holes were drilled in each, and one end of the jig was swung over to hole *A* and the holes drilled in it. This proved a simple and reliable means of drilling these and getting them all alike, as they should be, as the roller-plates were blanked and the holes in them pierced in the press.

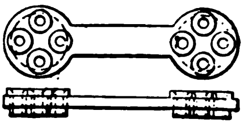


FIG. 85.

The steel shoe mentioned in the beginning of this description, for the base, was blanked and pierced in the press. So the degree of accuracy necessary in the laying out of the holes can be easily seen when it is understood that they were to go on either way, and leave an equal margin projecting all around outside the edge of the castings.

CHAPTER VI.

The Design and Construction of Drilling-Jigs for Heavy Machine Parts, etc.

CONSTRUCTING LARGE DRILLING-JIGS.

THE introduction of tools and fixtures for the production of duplicate parts of heavy machinery and tools has necessitated the devising of means and the designing of fixtures by the use of which the part, or parts, to be machined could be handled with ease and expedition. The result has been that where the proper design and construction of fixtures has been carried out, the finished work has proved vastly superior to that done by the old methods.

In designing and constructing drill-jigs for heavy parts there are a number of obstacles to be met and overcome, not found in jigs for the different classes of work shown and described in the preceding chapters. They are in effect as follows: In the increased size and strength of the jig castings. Then in the locating- and fastening-points for the work, which must be so situated as to allow the work to be located and fastened within the jig quickly, with the least exertion on the part of the operator. Lastly in the locating and finishing of the drill bushing-holes, which cannot (as a rule) be successfully accomplished by the same means used in the construction of jigs for small parts.

JIG FOR DRILLING A NAILING-MACHINE CROSS-HEAD.

The numerous and various jigs shown in the accompanying illustrations show clearly the most practical design and construction for the various shaped castings shown. In Fig. 86 are three views of a cast-iron cross-head for a nailing-machine. This is finished at three points, at *A A*, *B B*, and the bottom *C C*. The holes drilled are eighteen in number; four at each end at *D*; four at *E*, and six at *F* in the front projection. The jig for drilling them is shown clearly with the work fastened within it in the two views in Fig. 87. It consists of one casting with legs at each

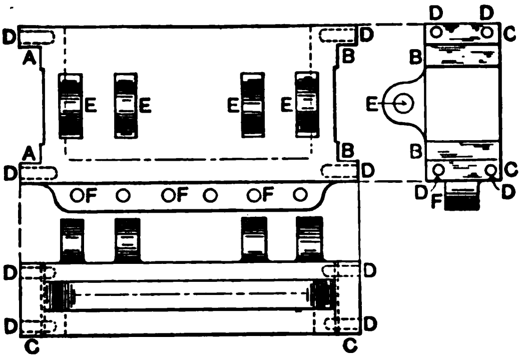
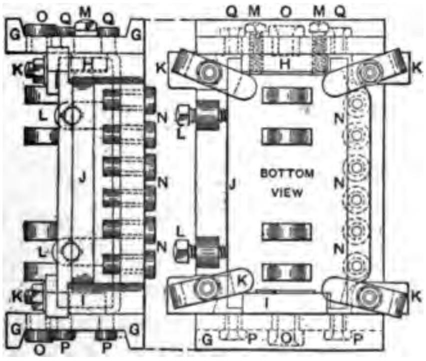


FIG. 86.

end at *G G*. The work is located by forcing it endwise against the two locators *I* and *H* respectively, by the set-screws *L L* (see view, Fig. 88). Four straps, *K K K K*, fasten and hold down the work securely on two raised and finished spots in the bottom of



Group

FIG. 87.

the jig. The bushing-holes are located and finished by the method described in the beginning of this chapter. When in use the work is fastened within the jig by slipping it down on the locating-points and tightening all screws and clamps. The jig is then stood on end on the legs *G G* and the holes are drilled through the bushings *Q Q*, after which it is reversed and the holes in the opposite end drilled through the bushings *P P*. The large holes through the four projections are then finished by inserting a boring-bar through the bushings *O* and the cored holes in the four projecting lugs of the cross-head, in which four cutters are fastened, one end of the cutter-bar being fastened in the drill-press spindle, and the other end running in and passing through the hole in the centre of the table, as the bar is fed down. The jig is as simple as possible, and allows the work being very rapidly located, fastened, drilled, and removed. The projecting lugs on the sides for the straps or clamps *K K K K* strengthen the ends of the jig, and overcome the tendency to weakness in the projecting ends. The use of a boring-bar with four cutters for finishing the holes *E*, Fig. 86, is both economical and productive of good results, saving time in the finishing of the holes and insuring their alignment with each other when finished. The use of the clamps for fastening the work tends to the rapid fastening and releasing of the same, as by a single turn of the nuts they can be swung on or off.

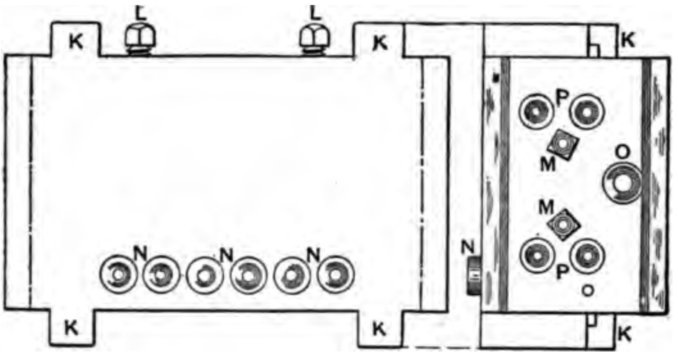


FIG. 88.

DRILLING-JIG FOR CAST-IRON IMPRESSION ROLLERS.

In the two views of the cast-iron impression roller in Figs. 89, 90, we have a piece of work that would be difficult to handle without the use of a jig. The roller is turned and finished in the lathe and then transferred to the miller and indexed for six, and the four channels *T T T T* are milled down its entire length. In each of these channels six holes, *R*, are drilled and in the plain side of the roller four counterbored holes, *W*, are let in. The inside of the roller is cored out as shown by the dotted lines, with cored vents at *V V*. A 2-inch hole through the ends at *U U* acts as a journal-bearing for a revolving shaft. The jig is clearly shown in the cross-sectional view in Fig. 91, and in the top and end views of Figs. 92, 93. *X* is the main casting, *Y* the bushing-plate, and *I* the shaft on which the roller *Z* to be drilled is fastened. The locating-plate *C* revolves in the end *B* of the jig and projects through to the opposite side, the index-plate *P* being keyed to it at *G* and fastened by the nut *H*. The bushings *N* are for the six holes *R* in the channels, and those at *M* for the counterbored holes *W W*, Fig. 90. To locate the roller within the jig so that the channels in which the holes are drilled will be in line with the bushings, the locator *D* is used. It is fastened within a channel in *C* by the cap-screw shown, piece *D* fitting the channel *E* snugly, as shown in the cross-section; while the roller is fastened to the shaft *I* by the set-screws *K*.

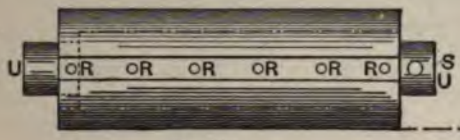


FIG. 89.

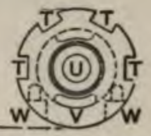


FIG. 90.

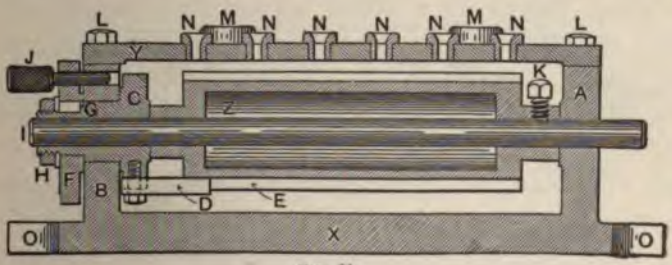


FIG. 91.

In the end view of the jig, Fig. 92, the indexing-holes in the plate *F* are shown—those for the holes in the channels are at *R R R*, and the one into which the index-pin *J* is entered, four

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in all. That for the counterbored holes is at *Q*. The top view of the jig shows the position in which the bushings *N* and *M* are located, and the manner of locating the bushing-plate by the four screws *L* and the two dowel-pins *P P*. By reverting to Fig. 91, the manipulation of the jig when in use, and the drilling of the work will be understood. The shaft *I* and the roller *Z* are inserted, fitting between the locating-plate *C* and the finished hub on the end *A*, with the locator *D* in the first of the channels. The shaft *I* is then slipped through and set-screw *K* in the roller tightened. The jig is then set on the table of a large adjustable multiple spindle-drill; six of the spindles being set so that the drills will enter the six bushings *N*, and four of the remaining spindles so set that the counterbores will enter the bushings *M*. The jig is then fastened securely to the press table by cap-screws through the ends at *C*. The four holes *W* (Fig. 84) are then counterbored, first removing the drills from the other six spindles. The counterbores are then removed, the six drills refastened to the spindles, and the index-plate revolved until the first channel in the work is under the bushing *N*. Index-pin *J* is now entered and the six holes drilled, when the index-plate is moved for the next channel and the holes drilled in it, the holes in the remaining two channels being drilled in the same manner. The use of this jig together with the multiple spindle-drill makes the handling and drilling of the heavy roller a simple operation, that would, however, be difficult to perform satisfactorily by any other means. Moreover, the work produced will be found to interchange perfectly.

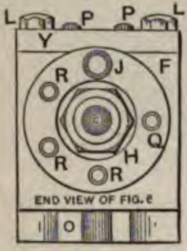


FIG. 92.

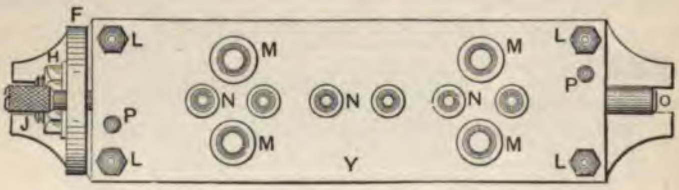


FIG. 93.

DRILLING-JIG FOR DOVETAILED SLIDE-BRACKETS.

A separate and distinct type of jig for heavy work is shown in the three views in Figs. 94–95. It is used for drilling all the holes in the dovetailed slide-bracket shown in Figs. 96–97, and, as will at once be seen, can be located on the work simply and rapidly. The bracket (Figs. 96, 97) has four holes drilled at *V V V V* and two at *W W*. The four holes *V* are for fastening the bracket to the body of the machine of which it forms a part, and those at *W W* for fastening a spindle-bearing to the portion on the bracket. The casting, before being drilled, is machined on the back at *U*, planed dovetailed at *S S*, and a cut is taken off the top at *T T*. The dovetailed surface is utilized as the positive locating-point for the jig, as it is shown secured in the work in the two views of Fig. 95. The bottom of the jig and the point *Z* are finished to coincide with the dovetailed surface of the work. The angular-faced clamp *A* is forced up against the work by the two set-screws *B B* and drawn up tight by the clamping-lever and stud *C*. The end locating-point is at *D*, which consists of a flat steel plate fastened to the overhanging end of the jig by two flat-head screws. The four bushings *F F* project down almost to the face of the jig, this being necessary, as the casting at this point is not machined. When being drilled, the casting rests on the back *X* and the jig is located and fast-

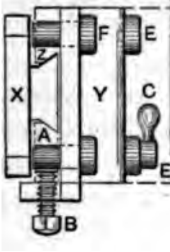


FIG. 94.

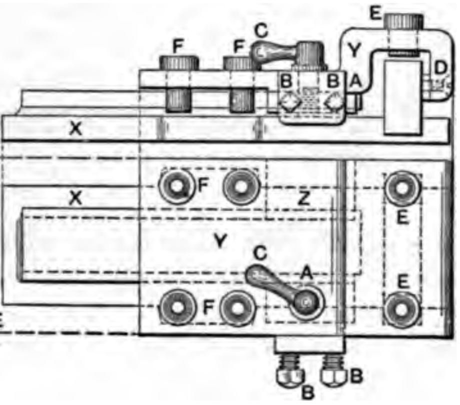


FIG. 95.

ened on it as shown in Fig. 95. The holes drilled, the jig is quickly removed by loosening the two set-screws *B B* and the clamping-lever *C*, which allows the clamp *A* to be slid back and the jig removed. The design of this jig gives a practical illustration of how simple and inexpensive tools for the drilling of heavy parts can be constructed, by choosing the most adaptable locating-points on the work, and designing the jig castings so as to have as few points as possible to machine. When locating and finishing the bushing-holes in this jig, it was first finished at all points necessary, and then clamped to the slide-bracket, or work, which was in turn clamped to the miller-table, with the top of the jig up. The holes were then located and finished by getting the distances from the machined surfaces of the work and using the vertical attachment, thus doing away with the necessity of first laying out the holes on the work, then finding their location in the jig. This is a very good plan to follow when the shape of the jig castings will not allow of their easy fastening to the miller-table. Moreover, in getting the distances between the bushing-holes, the machined surfaces of the work are reliable points to measure from.

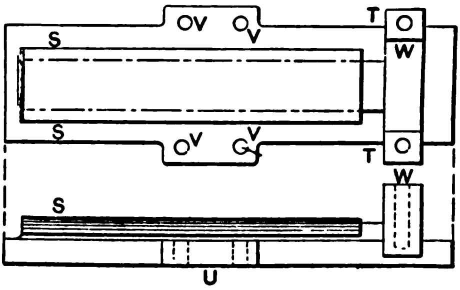


FIG. 96.

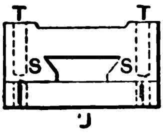


FIG. 97.

DRILLING-JIG FOR POWER-PRESS BOLSTERS.

Fig. 99 shows still another jig, in two views. It is for drilling all the holes in the press-bolster shown in Fig. 98. The casting, as can be seen, is a rather difficult one to handle; but by the use of the jig the drilling is accomplished with ease and expedition. The only finishing done on the casting before drilling, is to plane all sides of the two oblong projections, as shown at *A A*, *B B*, and *C C*, to gauge. The holes drilled are the four *D D D D* and two *E E*, and one through each of the projections *F F F F*.

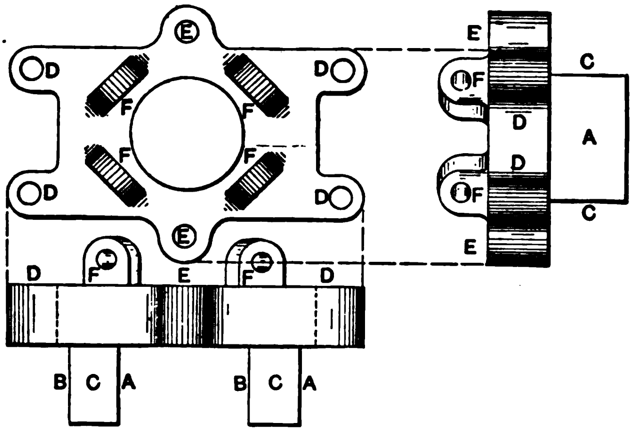


FIG. 98.

The jig (Fig. 99) is in two parts, the lid and body casting.

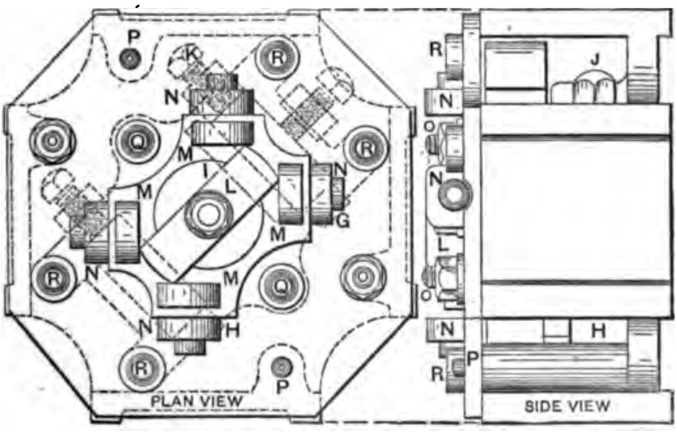


FIG. 99.

There are legs on four sides and on the bottom. The casting to be drilled is located from the two oblong projections on the back, as shown in the plan view, by the locating-spots *C I* and *H* and the set-screws *K K* and *J;* the large strap *L* holding it securely in the bottom of the jig. The lid is located by the two nuts *O O.* The bushings *N* through each of the projecting lugs on the face of the lid, are for the holes through *F F F F* in the work. The four bushings *R* are for the holes *D* and those at *Q Q* for the holes *E E.* When the jig is in use the work is located and fastened within it, as shown by the dotted lines in the plan view in Fig. 99. It is then rested on its back and all the holes in the face are drilled. The holes in the projecting lugs of the casting at *F* are drilled by standing the jig on each of its sides in turn and drilling down through the bushings *N.* In this jig the amount of time taken to locate, fasten, and then drill the work amounts to very little when the shape and bulk of the casting is considered. Jigs of this design can be used to the best advantage for the drilling of heavy castings on which are a number of projecting lugs, and when holes are drilled in them to a given line, or in line with each other, as in the case of the casting drilled in this one.

POINTS TO BE REMEMBERED.

In constructing tools of the class described in this chapter a few things must be considered: first, to construct the tools as simple as possible and to make them positive, so that they can be handled by cheap help without the possibility of going wrong. Also, in choosing locating-points on the work for the jigs, take the same ones (wherever possible) for all succeeding operations, thereby eliminating, as far as possible, the margin of error which may be the result of preceding operations. For instance, let us consider the upper columns of drill-presses: The first operation on such parts is the planing of the angular faces of the columns. These faces are then used as locating- and truing-points for the succeeding operations of milling and drilling. Therefore, if, when the columns were set upon the planer for the first operation, they were not set square with the ends, the error was overcome in the machining of the ends in the next operation. Another thing, tools of the kind shown should always be made as strong as possible, so as to withstand rough usage without in any way affecting their accuracy. If the tools are delicate, the time wasted in caring and looking after them offsets that saved in the machining of the work by their use. Also have a place for fixtures where they may be put out of the way when not in use; do not have them encumbering the floor, as is all too frequently the case in a number of shops. This will tend to lengthen their life, and it will not be necessary to hunt all over the shop whenever they are wanted.

CHAPTER VII.

Drilling-Jigs of Novel Design and Construction.

HAVING in preceding chapters fully described the most expedient means for accomplishing accurate results in designing and constructing the more familiar class of drill-jigs, as well as illustrated numerous types, I will show in this chapter a number of jigs of special and novel designs and describe means for their proper making and rapid operation.

DRILLING HOLES IN A SPIRAL LINE AROUND A CYLINDER.

Fig. 100 shows two views of a jig used for drilling the holes *A A* and *B B* in the roller Fig. 101. As will be seen, the two sets of holes are drilled entirely around on a $\frac{3}{4}$-inch pitch spiral, right and left respectively. When finished the rollers have hardened pins inserted in the holes, and act as cams for

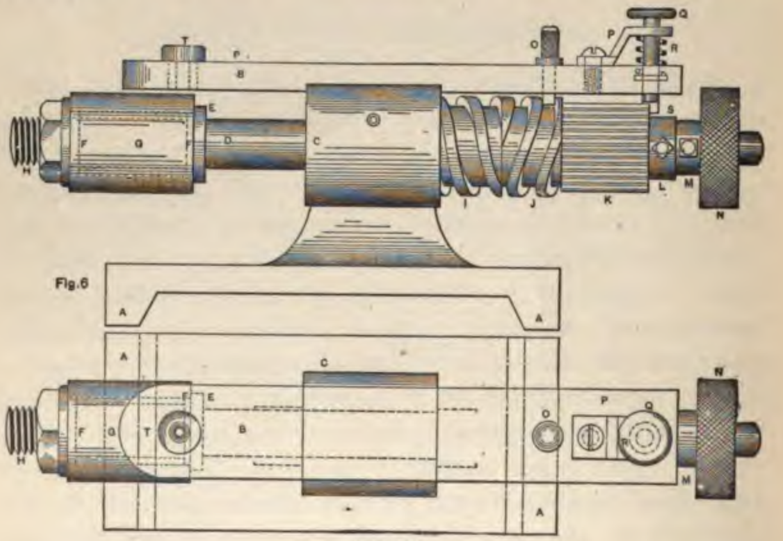


FIG. 100.

moving small slides of an automatic machine. The jig, Fig. 100, although simple in design and construction, is very accurate in production, and possesses some novel features seldom met with in drill-jig design. The jig consists of the body casting, of which *A A* are the legs, and *B* the bushing- and pin-plate. The roller to be drilled is fastened on the spindle *D* by the nut shown. This spindle moves freely in the casting at *C*. The right and left worms *I* and *J* are cut to a ¾-inch pitch, and are fastened to the spindle. The indexer *K* is of machine steel, indexed to twenty-six and fastened to the spindle by the set-screws *L*. The index-pin *Q* is fastened within the bracket *P* and is finished on the end to fit the index-notches in *K*, the spring *R* keeping it down tight. The worm-stud *O*, of tool steel, is finished to fit the worm snugly; the head is knurled, and it is then hardened. The end of the spindle *D*, on which the work is fastened, is finished with a shoulder at *E* and two smaller ones at *F F*, the space between these two being reduced to a size sufficiently small to allow for clearance for the drill as it comes through the work. The drill-bushing *T* is let in the top *B* so that when the spindle projects to its furthest point the first hole drilled will be the exact distance required from the end of the work.

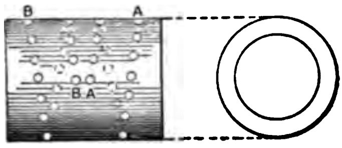


FIG. 101.

When in use the work is fastened on the spindle and the index-pin *S* is placed in the first notch of the index-sleeve *K*, that is, in the position shown in Fig. 100. The first hole is then drilled. The pin is now entered into the next notch and the next hole drilled. And so on until complete circles of holes are drilled entirely around the work; the stud *O* in the worm feeding the spindle-back as the holes are drilled. As the last one in the first circle of holes is drilled, the spindle is slid in by hand and the stud *O* enters the worm *I*. The spindle is then revolved in the opposite direction, and the other circle of holes drilled in the same manner as the first. The work is then removed, and the spindle fed back to the starting-point; another roller blank is fastened on the spindle, and the operations repeated as before. This jig can be adopted for the drilling of holes, on a given pitch, in circular pieces of work. Bushings to the number of circles required may be used. The one thing necessary is to have them spaced and located exactly the same distance apart; which should be the same as the pitch of the worm.

INDEXING-DIAL JIG FOR DRILLING SMALL CAMS.

Figs. 102–103 show three views of a jig in which the indexing-dial principle is utilized for the rapid drilling of the small cam, Fig. 104. This jig is so constructed as to allow the work when finished to be self-releasing. It consists of a body casting *A* planed and finished on all sides, and having legs *B B* scraped.

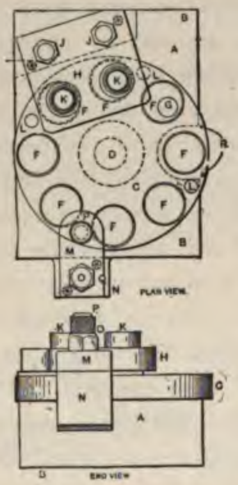


FIG. 102.

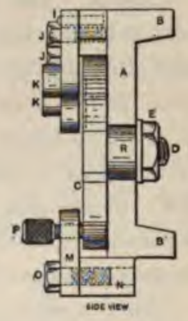


FIG. 103.

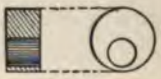


FIG. 104.

It is bored to admit the stem *D* of the index- and receiver-plate *C*, which has eight holes *F* bored and finished to allow of the work to be drilled fitting nicely within them, and thereby acting as receivers. The four holes *L* are the indexing- or spacing-points, and are all reamed to exactly the same size. The bushing-plate *H* is fastened by the dowel-pins *I I* and the two cap-screws *J J*. This is done before locating and finishing the bushing-holes. The bushings *K K* are let into the plate *H*, as shown, and are ground and lapped to size. Care is necessary in the locating and finishing of the bushing-holes to get them in the exact position required, as it is necessary to have the holes in the cam eccentric to a given size. The index-pin *P* fits snugly in the hole in the plate *M*, and the holes *L* in the index- or receiving-plate. The spacing and locating of all holes for the bushings, index-pin, and receivers for the work are accurately accomplished by the "button method" on the dividing-head of the universal milling-machine, in the manner described in a preceding chapter. The receiver-holes *F* are all finished to size with a special reamer.

When in operation one of the pieces to be drilled is placed in each of the eight holes or receivers *F*. The dial is then fed around until the first two places are under the bushings *K K*, when the index-pin *P* is entered into the hole *L* and the two pieces of work are drilled. The index-pin is now removed; the dial revolved one space, and the index-pin re-entered. This brings the next two pieces under the bushings. The piece drilled drops through the jig at R; the bottom of the jig being cut away at this point, as shown by the dotted lines. The second piece drilled remains at *G*. Now the dial is moved around and the empty receivers are filled, as the finished work drops out. As will be readily seen, the design of this jig allows of the continuous drilling of the work, without loss of time in the removal of same when finished. Moreover, the placing of the work in the empty receivers can be accomplished very rapidly, which is one of the best features of the jig, as this part of the work is quite a factor in the rapid handling and production of small parts by drilling. This jig can be used to advantage for the drilling of holes in small parts which have been previously machined to a uniform size. For the drilling of work in which great accuracy in the product is desired the indexing- or spacing-holes in the dial should be equipped with hardened-steel bushings, which should be lapped to a size allowing of a snug fit for the index-pin, thus insuring the accurate locating of the work and the positive fastenings of same while being drilled.

JIGS WITH INDEXING-PLATES.

In the jigs shown in Figs. 106, 108, 109, respectively, we have two more adaptations of the indexing-dial principle for a separate and distinct class of work. These possess features and attachments which in design and construction are not found in any of the jigs previously shown. That shown in Fig. 106 is used for drilling all the holes (except the centre one *C*) in the spider casting, Fig. 105; that is, those marked *B* and *A*, through the projecting lugs. The design of this jig is clearly shown in three views, and the method of construction can be readily understood from the description of the others. When in use the casting, Fig. 105, is fastened on index-plate *H*, Fig. 106, by entering into the stud *K*, and then fastened by a nut at *L*. It is located against the small projecting piece *O*. The index-pin *U* is then entered in one of the holes *N* by feeding the index-plate around the desired distance by worm *C*. The holes through one of the projecting lugs *B*, Fig. 105, are then drilled through bushing *P*. The jig is now stood on the legs *R R R R*, and one of the holes *A* is drilled through the bushing *Q* at the back. Index-pin *U* is pulled out, the dial fed around one space, and the next two holes are drilled. Index-pin *U* is equipped with a spring which keeps it tightly down on the plate. The nine holes *M* are clearance-holes for the drill, and are finished slightly larger than the hole in bushing *Q*. The index-plate *H* is a good fit between the front and back of the jig, to allow it to revolve freely without play on its face. The bearings for the worm-shaft are cast on the edge at *B B*. The main casting is cut away at *E*, as shown, in order to allow of the handle *F* revolving freely.

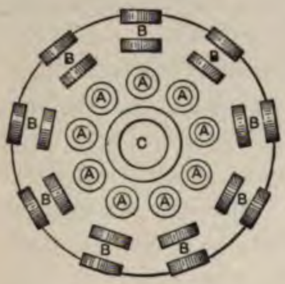


FIG. 105.

This jig can be used for drilling a number of different sizes of castings of the same shape; that is, with the number of projections reduced or increased by changing the index-plate, or, better still, by finishing it with a number of different circles of holes. This will allow of indexing any number of holes in the casting to be drilled—within its capacity—or for the drilling of regularly spaced holes in castings of a circular or irregular shape. The use of the worm for revolving the index-plate, although not absolutely necessary, is far preferable—whenever the quantity of work to be drilled will allow of the extra expense—

to the usual way of revolving the plate by hand; for by having a worm a fair fit in the hobbed rim of the index-plate, it contributes to the strengthening and rigidity of the plate while the work is being drilled.

In Figs. 108–109 we have the other adaptation of the dial principle, as used for the finishing of work in a manner entirely different from any other before shown. The piece machined in this jig is shown in Fig. 107. It is a drop-forging and is first machined at three points at the back at *A A A* on a milling fixture. The centre hole *S* is bored and reamed to size, and the top *C* is faced in a special chuck in the turret-lathe. The remaining

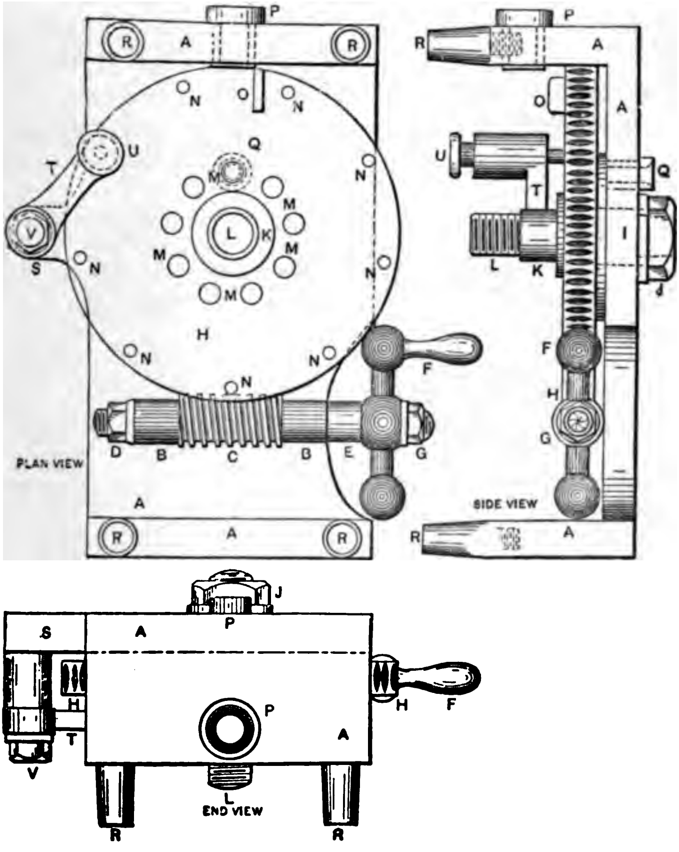


FIG. 108.

operations necessary to finish the piece are all accomplished by the use of the jig shown in plan and cross-sectional views: *i.e.*, the drilling of the hole *D*, Fig. 107, in the centre of each end; the facing of the top; the finishing of the parts *E* by a hollow mill; the facing of the wide surface of shoulders *F*, and the finishing of the half-round bearings *G G*. As this jig is of a novel and special design, a detailed description of the practical points necessary to its successful construction is essential.

The body or base of the jig is of cast-iron, with a slot *B* at either end for clamping it to the drill-press table. The three raised surfaces *E* and *F F* locate the work. The lugs *C C* are the side locating-points, and those at *D D* are for the set-screws *H H*. Base *A* is first planed on the bottom, and the projections are finished to the height shown. It is now strapped on the lathe face-plate, and bored and threaded for the central locating- and fastening-stud, which is of tool steel, turned and finished to the shape shown. This stud is threaded at *S* to screw tightly into base *A*, and at *R* to fit the centre hole in the work *O*, and is reduced for the rest of its length to the size shown at *Q*. Finally, the end *C* is threaded for the nut *V*. The locating-points *C C* are finished so that when the work *O* is forced against them by the set-screws *H H*, it will be in the position shown in the plan view of Fig. 108. The dial or bushing-plate *P* is of cast-iron, finished all over, and bored and reamed in the centre to fit snugly the locating-stud *Q*. The holes for the six bushings *I I K K* and *J J* are located and finished to the size required on the lathe face-plate, care being taken to get the centres of all six on the radius required, and to space them accurately. Next, the

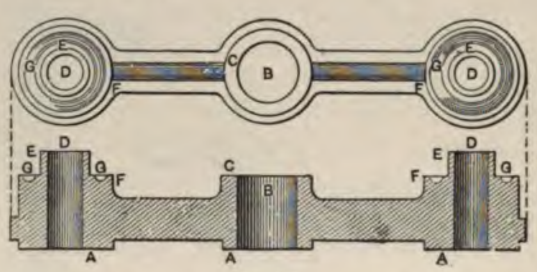


FIG. 107.

bushings are made, hardened, ground, and lapped to size, and forced into their respective holes in the plate *P*.

Before locating the six indexing-holes *L*, one of the forgings, Fig. 107, was laid out and strapped on the lathe face-plate, and

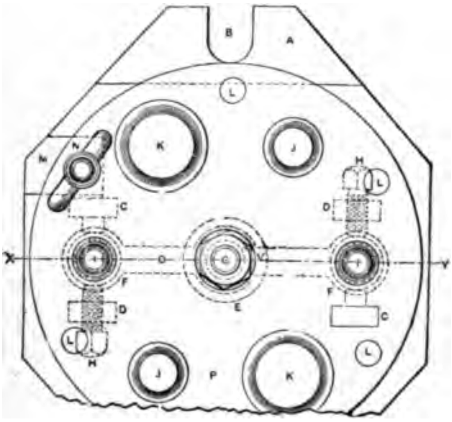
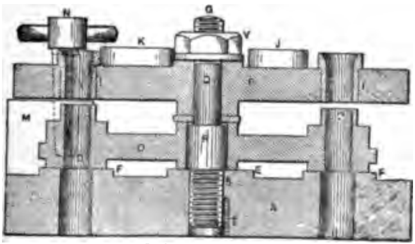


FIG. 108.

the hole *D* at either end bored and reamed to size. This forging was then fastened within the jig, Fig. 109, and used for locating the first index-hole in the following manner: Two steel plugs were turned to size, to fit the bushing *I I* and the holes *D D*, in the work. By inserting these plugs through the bushings, the bushing-plate *P* was accurately located rigidly in position. The first index-hole was now drilled through the plate *P* and into the projection *M* of the base *A*. Next, the hole was



SECTION ON X Y

FIG. 109.

reamed with a taper reamer until the taper-locating or index-pin *N* entered to the depth shown by the dotted lines in the cross-section, Fig. 109. Bushing-plate *P* was then removed, and the five remaining index-holes *L* located and reamed to size on the dividing-head of the universal milling-machine. All the parts were assembled, as shown in the two views, and the jig was complete and ready for work.

For use the jig is bolted on the table of an adjustable multiple spindle-drill, and two of the spindles set so that the drills will enter the bushings *I I*. The arms of the drill-press are adjusted to bring the spindles into proper line and are then clamped. The holes *D D* in the work, Fig. 107, are drilled, then the drills are removed, the nut *V* loosened, and the bushing-plate *P* is revolved one space. Index-pin *N* is now re-entered and nut *V* tightened, which brings the facing-bushings *J J* in line with the work. The top being then faced, the plate is revolved one space and the bushings *K* are brought in line. Next, the lower shoulder of the work is faced and the bearings *G G* finished, after which the work is removed, another piece located, and the operations repeated as before. As will be seen, the use of this jig insures the accurate finishing of the work and its perfect interchangeability. Jigs of this design can be used to the best advantage on multiple spindle-drills.

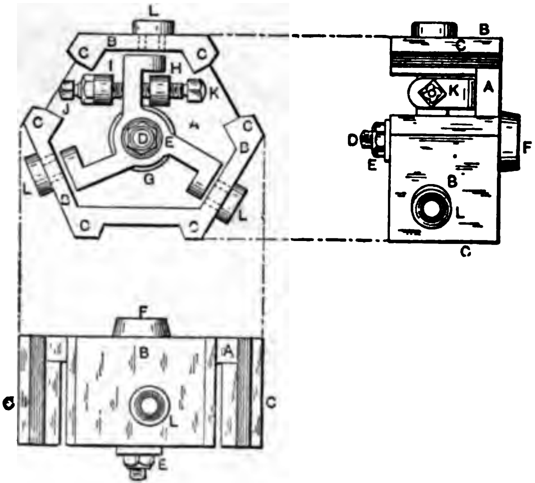


FIG. 110.

DRILLING HOLES IN A SPIDER CASTING.

Fig. 110 shows three views of a jig that is self-explanatory, and is merely illustrated to show how the drilling of a number of holes in a piece at a given angle to each other may be accurately accomplished in jigs of the simplest construction. The work, Fig. 111, is fastened within the jig on the stud *D* as shown in Fig. 110, and located against the adjustable-screw *I* by set-screw *K*, which allows of the rapid locating and removal of the work. When the jig is in use the nut *L* is removed, the piece to be drilled slipped onto the stud and located on a raised flat surface on the inside. The jig being stood upon the first pair of legs *C C*, the first hole is drilled. It is then stood on the next pair of legs, and another hole drilled, and then the operation is repeated for the third hole.

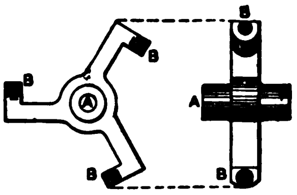


FIG. 111.

A DRILLING- AND TAPPING-JIG.

The jig shown in Figs. 112, 113, and 114, was for drilling and tapping cast-iron hoods of the shape shown in Fig. 115. There are three bosses projecting from the hood, equal distances apart, and these bosses were to be drilled and tapped to ⅜-inch, and it was necessary to have them accurately spaced. After

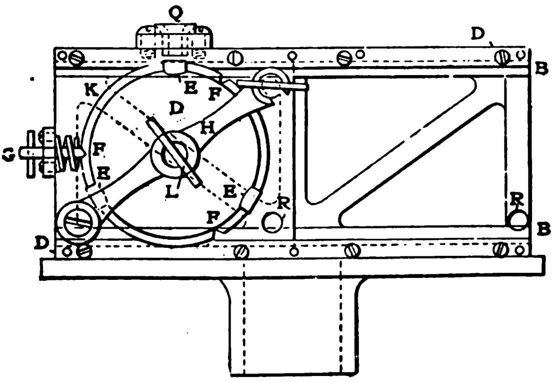


FIG. 112.

they were drilled and tapped, a ⅜-inch tube was screwed on to each of the holes and the tubes were each reamed for a piston, the three pistons meeting in the centre, as shown in the bottom view of Fig. 115. The pistons were worked by an eccentric and formed a part of a motor. As will be seen, a piece of this shape was hard to handle and required reliable means for holding it.

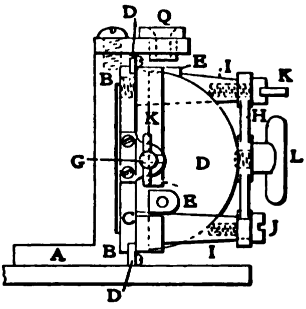


Fig. 113.

The main piece or frame of the jig was the casting *B*, well ribbed and strong, with a good, stiff base *A*. After the base was finished it was planed on the front, for the slide was of cast-iron, and was planed and fitted to slide nicely within *B B*. A hole *M* was then bored in the centre of *C* and tapped. Two gibs *D D* of machine steel were made and fastened with screws and dowels, and scraped until the slide *C* would slide freely. The locating-disk *K* of cast-iron was then made, as shown in Fig. 114. It was first bored in the centre for the shoulder-screw *N*, and then turned and hollowed out to just the size of the rim of the hood, Fig. 115, leaving a wall all around. The back was faced off and relieved at *O O*. After that it was set up in the miller and indexed accurately, locating and milling three *V*'s at *F*. It was also indexed in thirds at *P*, to give clearance to the lugs of the casting. It was then fastened so as to revolve freely, without play, on the face of the slide *C*, turning on the shoulder-screw *N*. The spring-lock *G* was then made and fastened to the side of *C*; so that, when locked, one of the lugs of the work would be directly under the bushing *Q*. The project-

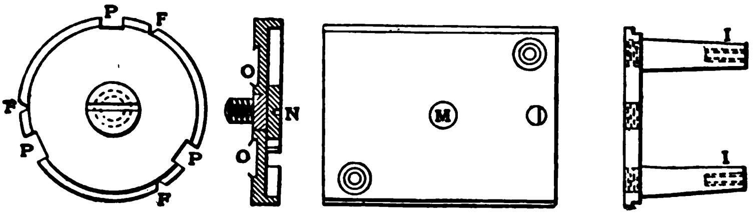


Fig. 114.

ing piece of the bushing was fastened with screws and dowels, and the bushing driven in. The two studs *I I* were turned and threaded at one end to screw on to the shoulder, on the face of *C*. They were then tapped out at the other end for the two screws shown. A hole was drilled and tapped in the centre for the lock-screw *L*. The parts were then all assembled and the hood placed within *K*, the three lugs fitting into the slots *P*. The locking-latch *H* was swung on, and the plate *K* moved around until the lock-pin *G*, which was equipped with a light spring, entered one of the *V*'s. The lock-screw *L* was then tightened, and the work was held fast. The jig was clamped on the table of the two-spindle drill-press by a *C*-clamp at each end, and the hole drilled through the bushing into the work. The jig was then removed and a stud the size of the hole entered, through the bushing *Q*, into the hole in the work. A hole was then drilled at *R* and reamed taper through the slide *C* into the back at *A*, for a tool-steel pin, which, when inserted through the taper holes, located the work central with the bushing. The slide *N* was then slid over the other end of the jig, and, when central with the other spindle, it was held there and drilled and reamed for the hole *R* as before.

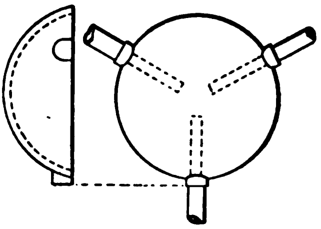


FIG. 115.

The jig was now ready for work, and it was set upon the drill-press and the work inserted. The taper-pin was then put in place, and the first hole drilled; then, on loosening the lock-screw *L*, the disk *K* was moved around to the next notch, the screw tightened, and the next hole drilled, and likewise with the other. The three holes being drilled, a tapping attachment was inserted in the other spindle, and we were ready to go ahead. The slide *C* was moved over, the taper-pin entered into *R*, and the tapping accomplished by operating the same as before. The hood was then finished and removed and another inserted. The jig was easy to handle and the work was accurately finished. The idea of drilling and tapping in one operation added to its usefulness and value.

A NOVEL DRILL-JIG.

The work to be drilled by the jig here shown was a piece of steel 1⅞ inches long, with a ⅞-inch hole reamed through the centre, and there were sixteen holes, 22-drill-gauge, to be drilled as shown in Fig. 116; that is, entirely around on a ⅞-inch pitch helix. Then there were three holes from *A* to *B*, Fig. 116, so that when these were separated, as shown in Fig. 118, and finished on a milling rig, they would form two perfectly fitting cams, which, in a friction-clutch that we were making, would open and close by the aid of two fingers, not shown. Fig. 117 shows the jig complete.

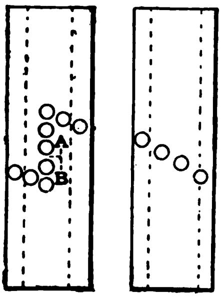


FIG. 116.

A is the table of the drill-press; *B* a clamp, showing how it was secured to the table; *C* the body, which was of cast-iron, planed on the bottom, with a hole through it for the shaft *E*;

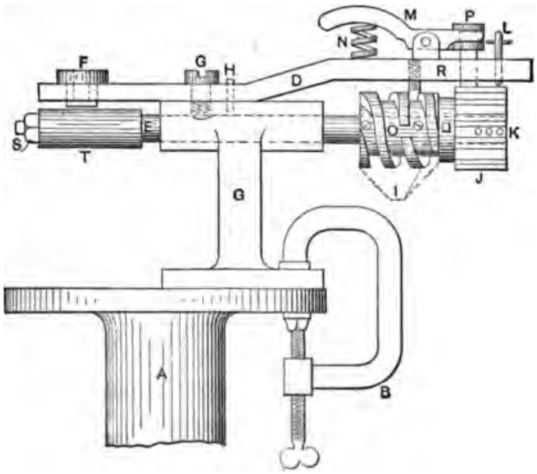


FIG. 117.

D a piece of flat machine steel, 1¼ inches wide by ⅜-inch thick, bent in the way shown and fastened to the body by two screws at *G* and the dowel-pins *H*. The index-plate *J* was a piece of machine steel 2½ inches in diameter, with sixteen grooves milled in it to admit the lock-pin *P*, and to square the holes evenly. The worm *I* was of iron, cut on a ¾-inch pitch, with a cross-groove at *O*. The pin *R* was driven into *D* and fitted smoothly the worm as shown. *M* was the lever for raising the lock-pin, and *N* the spring to keep it in the groove in the index-plate. *T* was the piece to be drilled, the shaft *E* being turned to fit the ⅞-inch reamed hole, and the thread cut on the end for the nut *S* to keep the work in place for the drilling. *F* was the bushing, to fit No. 22 drill. The index-plate was turned one space at a time and the pin *R* would, in the course of sixteen ¾-inch spaces, cause the worm *I* to make one complete turn on the ¾-inch pitch, when the pin *L* would be in line with the first of the three holes *K*, and the pin *R* in line with the slot in the worm at *O*. The pin *L* was then entered with the first hole, then the next by pulling the shaft out, and then the last, when it could be easily broken apart, the holes having all but run into each other. The worm and index-plate were secured by set-screws, as shown.

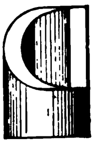


FIG. 118.

Four different sizes of cams were made, ¾-inch, ⅞-inch, 1⅛-inch and 1¼-inch, respectively; and all that was necessary to alter the jigs was to take off the worm and index-plate and replace with other sizes.

CHAPTER VIII.

Use of Milling-Machines for Modern Tool-Making, Interchangeable Manufacturing and Jobbing-Shop Work.

THE UTILITY OF MILLING-MACHINES.

THE development of precision machine tools to the present high state of efficiency is responsible more than anything else for the results which are now being attained in the making of tools and fixtures and devices for interchangeable manufacturing and the machining of repetition machine parts. The one machine tool which has contributed more than all others to the attainment of results in modern tool-making is the milling-machine—plain, universal, and vertical.

The utility of millers is by no means generally known. To a remarkable degree they are considered adapted only to tool-room uses or in making duplicate parts. As not every shop or factory has need for a strictly tool-making department, or turns out interchangeable work, investigation into the many uses for a miller in finishing ordinary, as well as special, work is not carried out as it should be. That they are capable, with attachments, of performing a wider range of work in jobbing-shops than perhaps any other machine tool, and at lower cost, is a fact that is now attracting the attention of progressive managers.

A well-designed milling-machine, properly constructed, is to-day recognized as one of the most important tools in every well-equipped machine-shop. Many operations heretofore done on a planer or shaper are now done much more perfectly and economically on a milling-machine, and for this class of work the use of end- or surface-mills has recently come into general favor, as this form of mill will remove metal very rapidly and leave the surface in good condition.

The horizontal-spindle machines in the plain or universal forms are in general use and familiar to all; and for many kinds of work, such as index-milling, or milling of any kind where work is carried on centres or held in head centre; making irregular or form cuts requiring the use of a series of cutters held on arbor which may or may not be supported by outward-arm; slot-milling, and a variety of operations called for in every-day practice, these machines with spindle in horizontal position meet all the requirements and are most convenient and effective.

Special machines, such as the Lincoln and modified types of this class, are in use for duplication of parts; but the two main types heretofore in use for general purposes have been the horizontal-spindle and the vertical-spindle machines, and, as stated, each of these classes have their decided points of superiority.

While the milling-machine has no claim to antiquity, the manner in which it has been adapted and used for all classes of fine work, and the rapidity with which it is becoming understood, have more than compensated for its late birth. Although the youngest of the machine-tool brood, it is now the most universally used one and can well be placed at the head of them all. The modern tool-room, where claims are laid to doing good work, that is not equipped with a universal milling-machine is to-day a paradox indeed. Still, notwithstanding the fact that nearly all shops have such machines, their use and manipulation are not generally understood; that is, we mean that the large and wide range of work possible to machine on them is not appreciated by mechanics in general.

When we state that the use and adaptation of the milling-machine are not understood as they should be, we do not refer to its use for the ordinary classes of work, but to special work such as jigs, tools, dies, and fixtures for the machining of repetition machine parts and also for economic manufacturing.

As one writer in *The American Machinist* has aptly said: "Of all the machines to be found in the modern tool-room the universal-miller stands pre-eminent. This is the machine of applied geometry. The combinations and positions obtained by means of a first-class universal are almost endless. A jig-body properly set up in a universal may be rotated, swung, twisted around, raised, lowered, moved laterally or crosswise, set to any angle, drilled, bored, reamed, faced, slotted, profiled, indexed, and in some cases completely machined and made ready for the bushings without changing the original setting. There is scarcely any problem in jig-making, no matter how intricate, that cannot be worked out on a universal with the greatest ease, and positive distances, angles, and arcs in every direction are only a matter of correctly reading the index-plates or wheels."

IMPROVEMENTS IN CONSTRUCTION.

During the past few years great improvements have been made in the construction of universal milling-machines, so that now they are adaptable for a larger variety of work than ever. As incentives to the further improvements of such machines, their use has been largely extended and their advantages for certain classes of work are becoming better understood. It is apparent that the constant aim of the designer has been to increase the range of universal milling-machines, and the result to-day is that they are used for a variety of work simply astonishing. The attainment of these results can directly be traced to specialization in manufacturing and to the employment of jigs, fixtures, and special appliances throughout in the production of the machines.

UNIVERSAL MILLING-MACHINES.

It is not so long since that the universal milling-machine was looked upon as a machine useful only for tool work, and a first-class tool-maker the only man to handle it. In a sense it was looked upon as a luxury which only a few shops could enjoy. To-day all this has changed and, while the machine is used for a larger and better variety of tool work than ever, it is in the production of repetition parts that its great value has become apparent. Thus this tendency to the universal use of the machines has given more and better work to the skilled tool-maker; for where large quantities of parts are to be milled, a special jig, fixture, or a device of some sort is, of course, necessary, in order that the cost of producing the parts may be reduced to the minimum. There are any variety of parts which can be rapidly and accurately machined by simple indexing or light-chucking devices on these machines; and as the economy in the production of even a small number of parts machined by their use usually more than pays for the cost of the fixtures there is no good excuse for their non-adoption.

To-day the proprietor of any machine, tool, or die manufacturing establishment who wishes to do everything possible to assure success must see first that his tool-room equipment is as complete as the demands of his specialty necessitate. He should also start out to do this with the conviction that it will not prove merely an additional item of expense, but, on the contrary, a department which will tend to increase the efficiency of his product. While the first cost of an up-to-date tool-room equipment is sometimes staggering to the person who pays the bills, the knowledge that through it he will be able to more than balance the expenditure in a very short time should set his mind at ease.

The universal milling machines now on the market have been designed and built to meet all requirements of tool-making and manufacturing, while the attachments which may be used with the machines make the doing of a special or an intricate job an easy matter. With the attachments now in use on the universal miller for rotary-milling, cam-cutting, rack-cutting, vertical-milling, under-cutting large gears, and a variety of other classes of work too numerous to mention, the making of tools of unusual accuracy, as well as the modern manufacturing of machine parts, can be carried on without trouble or worry on the part of the mechanic.

"KNEE TYPE" OF UNIVERSAL MILLING-MACHINES.

While fully appreciating the value and adaptability under certain conditions of the "Lincoln," "Slab," and "Rotary Planer" types of milling-machines, I devote the space at my command herein to the "Knee Type" exclusively. This type of milling-machine, on account of its wide range of work, has been adapted for tool, die, experimental, and fine machine work all over the world; and therefore, as the demand for this type of milling-machine has exceeded that for all other types combined, the tendency among the manufacturers of such machines has been to increase their range and to make them universal in every sense of the term.

The knee-type milling-machine is among the latest additions to the machine-tool family; but it has taken its place in thousands of progressive shops, where it is used to the best advantage as far as the knowledge of the art has progressed at this date, although there yet remain many shops where its advantages are not understood, and work is being done on other machines, or by hand, when it could be done on a milling-machine at a great saving in cost, if a little thought were given to the proper cutters and equipment.

The knee-type universal milling-machine will do a greater variety of work than any other machine tool, and a small experimental shop that can have only one machine will be best equipped with a machine of this class.

MILLING-MACHINES COMPARED WITH OTHER MACHINE-TOOLS.

Any work that can be done on the face-plate or in the chuck of a lathe can be done in a milling-machine by holding an ordinary lathe-tool in the swivel-vise. A pair of bevel-gears, for instance, can be bored, turned on the angles, teeth cut, and the gears finished complete without ever having been near a lathe. A steam- or gas-engine cylinder can be bored, faced, and finished complete, and the fly-wheel bored and turned in the same machine.

What a trying thing it is to see a machinist work up a number of parts on a shaper or planer and then see another spend a day or two filing and fitting to make them go together, while it takes a helper five minutes to mix them up and another machinist a long time to sort them out and assemble in their proper places.

By way of contrast, a boy could have made them absolutely interchangeable in the milling-machine, and they could have been drawn at random from the stock-room and assembled without filing, fitting, or loss of time.

Formerly it was supposed that a milling-machine in the tool-room constituted a full equipment in this line of machinery, but lately it is becoming known that improvements have been made greatly increasing the power of the spindle and feed, as well as adding innumerable conveniences, such as all automatic feeds constructed so as to be quickly changed from one to the other, and at the same time being impossible for any two to engage at once. The knee being box section, cast without hole through the top, gives the work-table sufficient rigidity to enable it to carry much larger work without chatter than would be possible with the old-style construction, and make many manufacturing operations not only possible, but economical.

An equipment for the rapid production of finished work on a milling-machine can be classified under three heads.

First: Strong, accurate machine with ample range and easy adjustments.

Second: Suitable fixtures for holding the work where the pieces are large or complicated so that they cannot be held in a vise or easily clamped to the table—(it takes skill to lay out and block up work on any machine). A suitable fixture makes it possible to use less skilled workmen.

Third: Well-designed cutters, and a good cutter-grinder to keep them sharp.

THE MILLING-MACHINE IN THE TOOL-ROOM.

The fate of many a manufacturing concern rests with its tool-room, for here are produced the jigs, dies, fixtures, boring-tools, reamers, etc., suitable for the specialties manufactured.

Do not consider it a necessary evil because it is classed as non-productive, for it is the equipment of well-designed, well-made tools that enables machine tools, standard and special, to come up to their highest efficiency, and place the factory in the fore-front.

The machine-tool equipment should be all that would be required to make a complete high-class small machine-shop, and the tool-making should be confined to it as far as possible rather than break up machines engaged in manufacturing.

MILLING AN ANGLE-PLATE.

Here the universal milling-machine is at home, provided it is a first-class machine and equipped with vertical-spindle and rack-cutting attachment. A machine of this kind will have the greatest possible accuracy, convenience, and range, and will be found adapted to every variety of tool-room work. A long automatic cross-range on a miller is also desirable, as it makes it an excellent tool for accurate jig-boring. Fig. 119 shows an angle-plate used on the face-plate of an engine-lathe for accurately boring a complicated piece that has two holes at right angles to each other. The angle-plate was first milled on the edge in order to provide a surface that would set square on the work-table. The hole on the back for the lathe-spindle plug was first bored, and the plate shifted to the position shown. It is obvious that these two holes will be exactly the same height from the edge of the plate, and the work when placed upon it will be in line with the lathe-spindle. If the piece had been a box-jig, a long boring-bar would have been used and the outer end supported in the overhanging arm. Usually it is better to make boring-bars to fit in the taper hole in the spindle, as the chuck takes up some room. The chuck method, however, is very convenient, as the boring-tool need be only a straight piece.

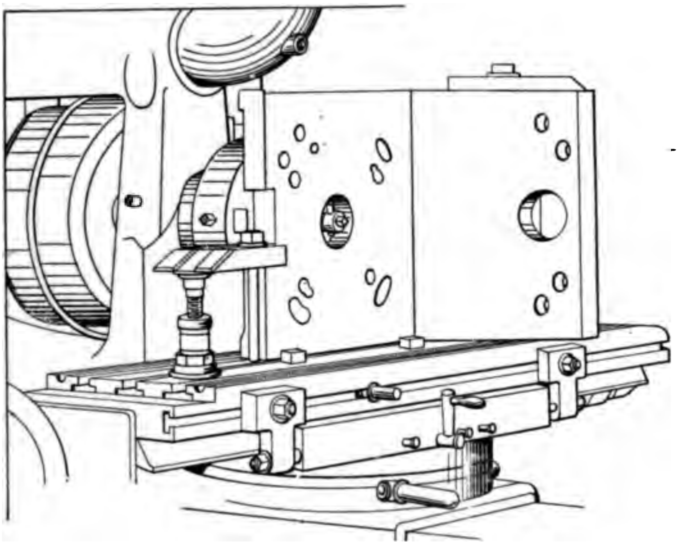


FIG. 119.

CIRCULAR JIG-MAKING ON THE MILLER.

It often happens that an accurate circular-jig is required so that the two pieces drilled will fit without matching holes. This can be quickly done, as shown in Fig. 120. Note that the dividing-head has cross-slot and side-ears so that blocking and strapping are unnecessary, and the large dividing-wheel insures accuracy.

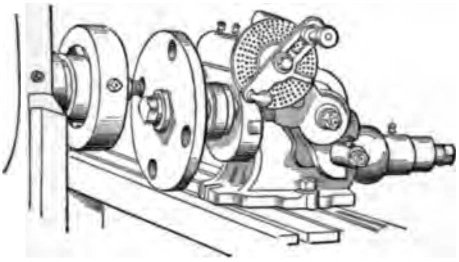


FIG. 120.

VERTICAL-SPINDLE MILLING-MACHINES.

In establishments where large numbers of machines, appliances, and parts of standard shape are produced, the chief desire is the increasing of the daily output without increasing the labor cost. This desire can only be gratified satisfactorily by using machines which can be kept constantly producing parts of the same shape and size. It is in shops of this class that the vertical-spindle milling-machine can be used to the best advantage for all work that can be produced economically by vertical milling.

As much time, skill, and money have been expended in the development of this type of miller, the advantages to be gained through its use are numerous, and are now almost universally recognized where economic production is imperative. The utility of vertical millers for machining surfaces and parts, once only thought possible to do on the lathe or on the planer, is steadily progressing, as the degree of precision to which the machine has been developed, namely, permanency of alignment of the spindle with the platen, makes the production of accurate and intricate parts by its use assured.

DOUBT AS TO THE UTILITY OF MILLING-MACHINES.

To those who are in doubt about the utility of milling-machines—plain, universal, vertical, and those in combination with other machines—for modern manufacturing, tool-making, and machine-jobbing, a trip of inspection through the establishments devoted to their production would convince them; as in such shops they "practise what they preach" and have adopted their own machines for the rapid and accurate production of parts of machines of the same kind with the most gratifying results, the machines being used to the exclusion of all other machine tools on all jobs permissible. Thus in those shops the milling-machine is practically self-producing, and stands to-day a monument to the ingenuity and skill of those men who conceived it and developed it to its present high state of perfection.

CHAPTER IX.

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SIX DISTINCT TYPES OF SIMPLE MILLING FIXTURES.

HAVING in preceding chapters described various types of fixtures and tools suited for machining different grades of duplicate work by drilling, I will now turn my attention to milling fixtures; and will devote this chapter to those adapted for machining the simpler grades of work in which no great accuracy is required, but which, at the same time, it is necessary to produce to a certain degree of interchangeability.

In the construction of tools and fixtures for the machining and duplication of interchangeable machine parts by milling, a number of obstacles must be overcome that are not met with in the fixtures and jigs described in preceding chapters. There are also, of course, a number of practical points in their design and construction which are absolutely essential to their successful operation; the conditions under which they are operated being totally different from those under which drilling-jigs and fixtures are used. It does not require as high-grade skill to construct fixtures for accurate milling as for accurate drilling, yet the designing of these fixtures entails considerably more thought and practical ability, to give satisfactory results.

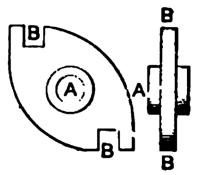

FIG. 121.

In Figs. 121, 122, and 123, are illustrated three samples of work milled by the use of inexpensive fixtures which may be aptly termed "emergency fixtures." The fixtures are shown in 124, 125, and 126. The design and method of construction are very simple, and are clearly shown in the illustrations. The fixture for milling the square channel at *B B*, Fig. 121, is shown in

Fig. 124. It consists of a square plate *L*, of ⅜-inch flat machine-steel, finished all over; of the central locating-stud *J* screwed tightly into the centre of the plate; of the end locating-pin *K*, and of the two dowel-pins *I I* which coincide with two holes drilled and reamed to size in one of the steel jaws of the miller-vise. The channel *L* is used as a guide for the cutter, and also as a gauge for the depth and location of the cut in the work. This fixture is located on the inside of the vise-jaw by the dowels *I I*, and the stud J is entered into the reamed hole *A* of the work, and one side of the rough-cast channel *B* set against the locating-pin *K* as shown. The vise is then closed and tightened against the work, and the cutter is set to enter the guide-channel *L* of the fixture, so that it will just touch the bottom of it. One end of the work is then milled; then the work is reversed on the fixture, so that the finished channel will locate against the stop-pin *K*, and the other end is finished.

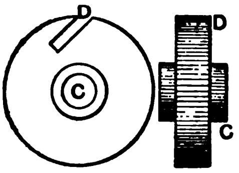

FIG. 122.

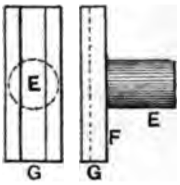

FIG. 123.

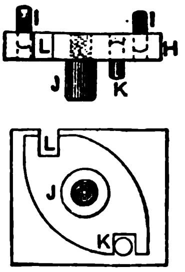

FIG. 124.

The other two fixtures shown in Figs. 125 and 126 are also constructed to locate on the stationary jaw of the miller-vise. That shown in Fig. 125 is relatively the same as the first, except that no stop-pin is required—the work, Fig. 122, being round and having but one slot, *D*, milled in the position shown. The hubs of the work are faced and the hole *C* is reamed to size, the outside being finished to a given diameter in the lathe before milling. Fig. 126 shows a fixture used for milling the channel in the face of Fig. 123. The two sections are of cast-iron. The largest one, *Q*, has a raised projection at one end, with a guide-channel *R* milled central with the *V* on the face. *S S* are the two vise jaw-dowels, and *T* the

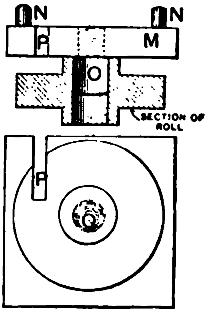

FIG. 125.

sideway locating-pin for the work. Both these fixtures are operated in the same manner as that shown in Fig. 124, and are adaptable for milling a large variety of small machine parts that are not required in large quantities, or in which a given limit of error is allowed, thus necessitating the utmost economy in the expense of the fixtures for their duplication. The efficiency and practical value of these three fixtures are at once apparent.

FIXTURES FOR MILLING A BEARING IN A BRACKET.

A plan and a side view of a simple fixture that can be adapted for odd-shaped castings are illustrated in Fig. 127. This fixture is used for milling the bearing and cap-surface of the bracket, Figs. 128 and 129, to the shape shown at *Y* and *Z Z* respectively, the bearing *Y* being milled to an exact half-circle of the radius required, so as to conform with its duplicate in the cap. This is afterward fastened to the bracket and the bearing

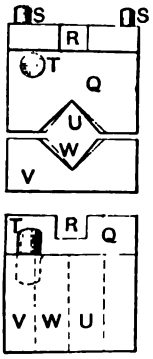

FIG. 126.

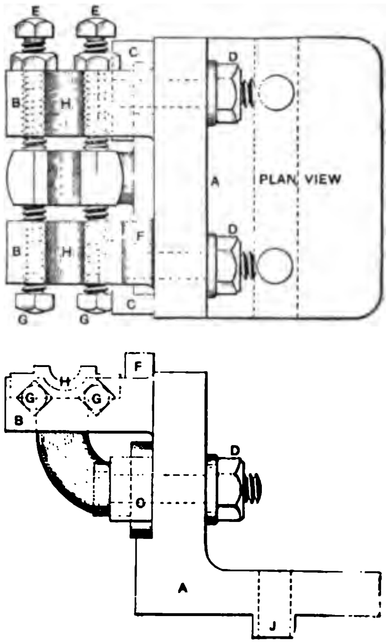

FIG. 127.

reamed to the finish size. The fixture consists of one main casting in the form of an angle-plate. When the base has been finished, the tongue *J* fitted to the central slot of the miller-table,

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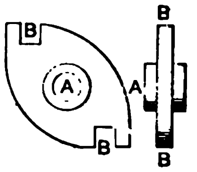

FIG. 121.

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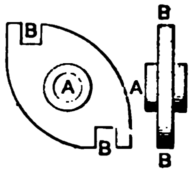

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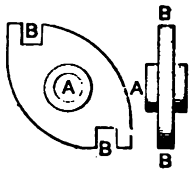

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to the best advantage; second, the manner of presenting the work to the cutters, and, lastly, the most expeditious and reliable means for locating and holding the work rigidly while being milled.

FIXTURE FOR USE IN GANG-MILLING.

A type of fixture used extensively for gang-milling, where wide surfaces or a number of depressions are to be milled in the face of castings that have not been previously machined, is shown in Figs. 135 and 136. Although of the simplest construction, it represents a useful type of milling fixture for the milling of a large variety of work that it would be difficult to machine rapidly by any other means. This fixture is used for the milling of the type of casting shown at *H*, Fig. 137, which consists of four channels *H H H H* in the face, and of the square channel *I* in one end; requiring two separate operations; both being accom-

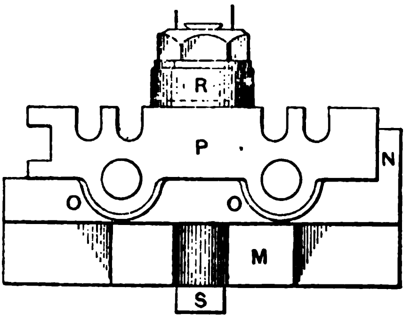


FIG. 136.

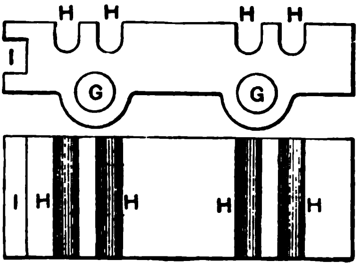


FIG. 137.

plished on the one fixture. Fig. 135 shows a section of the plan and side view, and also an end view of this fixture which handled eight castings at once. It consists of one large casting *M* having two half-round depressions running down its entire length as clearance for the projections on the back of the work. The top is planed true with the base as a squaring surface for the work, and ends in a square shoulder at *N* for the work to locate against. The work is held in position by clamps at *R R* so placed as to clamp two castings, as shown at *P P*. The holes for the bolts are counterbored at the back to allow the heads to clear the miller-table, as at *T T* in the side view, Fig. 135. The work is fastened as shown, and the square channel in the end is milled. When all the castings have gone through this operation, the four channels are finished by relocating and fastening the work to the fixture and setting a gang of mills. The cross-slide of the miller-table is then clamped, the depth of the cut set, and the castings finished.

FIXTURE USED IN FACE-MILLING.

Another type of simple milling-fixture is shown in the two views of Fig. 138. Although somewhat similar to that shown in Fig. 135 it is used for a distinctly different class of milling; that is, face-milling. The sketch shows it being used for ends *Y*

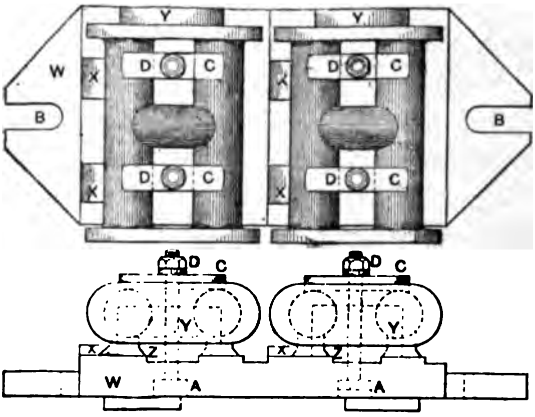


FIG. 138.

V of castings like Fig. 139. This casting is first set up on the planer and the dovetailed slide-surfaces *U U* are planed to gauge. The fixture is constructed to handle two castings at once, they being located sidewise by forcing the side of one of the dovetailed surfaces *Z* against the angular-faced locating-lugs *X X X X* as shown, and endwise against the squared and faced projections *Y Y* at the back. The castings are held in position by two clamps each, as at *C C C C*, and the heads of the bolts are let into the base, as at *A A* in the side view. The ends of the castings are faced by a large cutter-holder, with self-hardening steel cutters set into the rim, so that a roughing and finishing cut can be taken at the same time. When one end of the casting has been faced, they are reversed, relocated, and the other ends are faced.

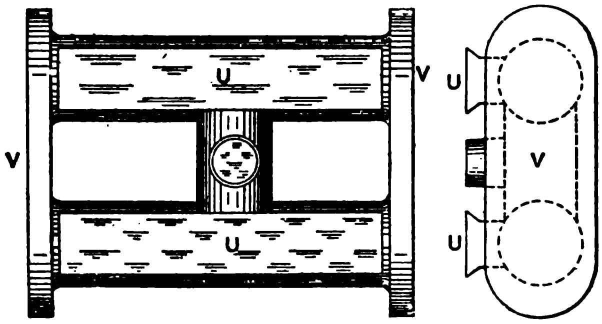


FIG. 139.

When the large variety of machine parts, both small and large, which can be machined in exact duplication of each other by the use of just such simple and inexpensive fixtures as are here shown is considered, it is surprising that these methods of manufacture had not been adopted more extensively. By this we mean in the small shop; for in the large shops, unless the machines or appliances are manufactured under patents, it is absolutely necessary to manufacture by the interchangeable system in order to meet competition.

CHAPTER X.

Milling-Fixtures for Accurate Work.

FACTORS IN THE SUCCESSFUL USE OF ACCURATE MILLING-FIXTURES.

WE are now about to take up a class of milling-fixtures of a different type from those described in the preceding chapter, in that they are more intricate and are also capable of producing more accurate results. When designing these tools there are three questions to be considered: First, are the parts which are to be machined required in large quantities? Second, must they be finished very accurately, so as to be interchangeable? Lastly, can the parts be handled and finished to the best advantage in the milling-machine?

The first two questions can be answered in very short order. But in deciding the answer to the last one, the knowledge and skill of the designer, who is often the constructor as well, are put to the test. If it is decided that the milling-machine is most suitable for the work, the following points must then be considered after the shape and type of fixture have been determined: The surface by which the pieces are to be located; the devices for fastening the work, and the most practical way of presenting the surface to be machined to the cutter or cutters, as the case may be.

As types of the most reliable class of milling-machine fixtures for duplicating small and medium machine parts, there are here shown five examples which are well designed for the particular pieces of work for which they are intended. The devices also are suggestive, in that many of their features can be so modified as to be applicable to work of other kinds. Methods for constructing the fixtures will be described—explaining how they can be produced within a reasonable length of time and at moderate expense.

FIXTURE FOR THE FIRST PIECE OF WORK.

The fixture shown in three views of Fig. 140 is used for facing the flat surface of the work, Fig. 141. The finishing of the ends of the piece is accomplished in the lathe, the parts *e e*, *d d*, and the threaded portions being interchangeable. The fixture, Fig. 140, for facing the flat surface *F* true with the turned portions of the work, is of few parts, and holds the work rigidly. As the method of construction is not very intricate, and can be understood from the illustrations, a slight description will suffice.

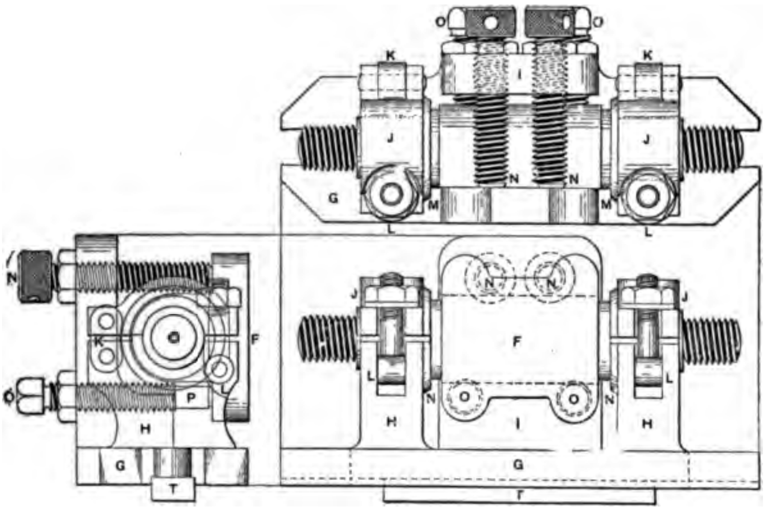


FIG. 140.

The fixture proper consists of the body castings *G*, the standards *H* between which the work is located, the back projection *I* for the fastening- and locating-screws *N N* and *O O* respectively, and the two clamping-lids *J J*. The lid clamping-screws *L L* are fastened in the slot in the standards, as shown in the face view, by means of Stub steel pins, so that they may be fastened and released as rapidly as possible. The lids *J J* are hinged as shown at *K K*. The locating-screws are of tool steel and are reduced at the ends as shown at *P*, in the end view, and hardened and equipped with jam-nuts. The tongue *T* is let into a slot in the body casting *G* so as to be perfectly in line with the turned portion of the work when within the fixture.

The boring of the standards and lids to size, and the facing of the surfaces *M M* so that the work will fit between them snugly, is accomplished in the following manner: The base is first planed and the body casting strapped to an angle-plate on the drill-press table. A boring-bar is then used with the end running in the bushing in the table, and the holes are bored and the shoulders faced. The two screws *N N* for forcing the work against the two locating screws *O O* have knurled heads with a spanner hole as shown, are threaded to screw freely in the tapped holes, and are also equipped with jam-nuts.

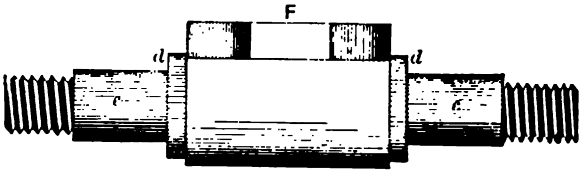
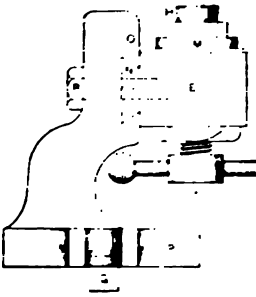


Fig. 141.

When using this fixture it is clamped on the miller-table with the tongue *T* in the slot nearest the spindle. The two lids *J J*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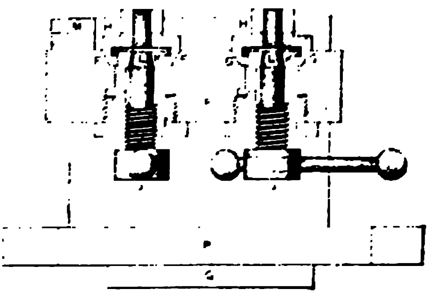

[illegible]

are then [illegible] back and the work inserted as shown. [illegible] tightening the [illegible] locat-ing screws *O O* [illegible] fasten [illegible] cross-feed [illegible] will remove the amount of stock required; and the face is milled, using a large face-cutter, running it so that the cut will be downward, thereby taking the strain off the fastening-screws *N N* and keeping the work against the locating-screws *O O*. The facing of work of this class in fixtures of the type shown can be accomplished to a greater degree of interchangeability and in less time than by any other means known to the author.

FIXTURE FOR USE IN MILLING THE SECOND PIECE.

In Figs. 142 and 143 we have a milling fixture of a more intricate type, and one which for rapid locating, fastening, and releasing of the work when finished, would be hard to beat, as one turn of the screw fastens or releases, as required. This fixture is constructed for the accommodation of two pieces at a time, and could, if required, be constructed for twelve on the same principle. The fixture was designed for milling work of the shape shown in Fig. 144. The piece was of machine steel and was finished, all but the milling, in the turret-lathe, and was used as a part of an electric cloth-cutting machine which was being manufactured in large numbers. The milling consists of a slot through the stem at *a* and a flat at either side of the largest circular portion, as shown at *b b*.

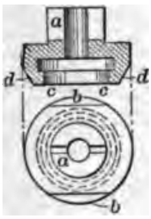


FIG. 144.

The fixture consists of two castings, *P* and *E*, and spring-chuck devices, of which *I I* are tool-steel pieces screwing into the casting *E* and carrying the spring-jaws *K*. These jaws are forced out against the work by the expanders *L L*, which screw into threaded holes in *I I*. The one point in the construction of this fixture most worthy of a detailed description is the manner of finishing the locating-depressions *F F* in the part *E*. This part is of cast-iron, with a projecting lug at *M* which is used when finished as a gauge for setting the three cutters which mill the work. This cast-iron block is first planed on all sides, and one side *X* finished dovetail, to fit tightly into the dovetailed channel milled in the body casting *P*. This channel, by the way, was milled on the front of the casting and faced, after the base had been finished and the groove for the tongue was milled, on the machine on which the fixture was to be used, to guard against inaccuracy.

The block *E* was driven into this channel and fastened by two screws, shown at *R*. The position of the centres for the locating-depressions *F F F F* were then located so as to be dead in line with each other by the "button" method described in a previous chapter. The depressions were finished and holes bored and threaded at the back by strapping the block *E* on the lathe face-plate, truing the "buttons," boring the holes, finishing the formed depression to exactly the shape and depth by means of a forming-tool, and then reversing the work and enlarging and finishing the holes at the back, as shown.

When the fixture is in use, the work is held down on the locating-face *F F* by hand, and the expander given a turn by the handle *J*. This causes the spring-chuck *K* to grip the work and draw it down on the locating-face. The cutters are then set by the gauge *M* and the work milled.

DESCRIPTION OF FIXTURE FOR THE THIRD PIECE.

In Fig. 145 there are two views of a piece which is an ideal job for the milling-machine. It is a cast-iron spindle-bracket, and the milling operation consisted of facing the fronts and backs of the two bosses, and finishing the projecting rib *H* at a certain distance from centre of hole *Q* and at a right angle with the hole *K*. Before milling, the hole *Q* is bored and one side of the hub faced in the turret-lathe. The opposite side is then faced and the two holes drilled through *g g* and one through *K*. The side *j* is faced in a special jig and all points machined are interchangeable.

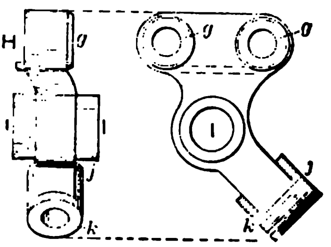
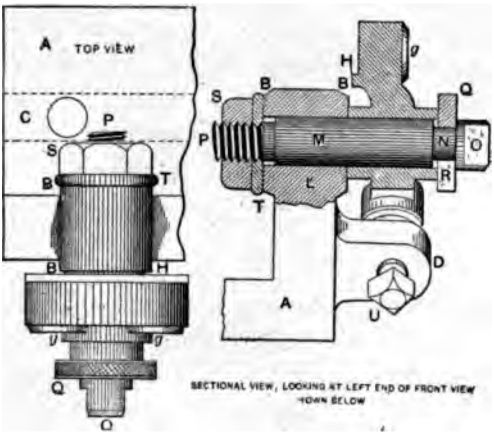


FIG. 145.

The milling fixture shown in Figs. 146–147 is designed to hold two pieces of work at once, and can be constructed for the accommodation of a dozen, if desired. One casting, *A*, is all that is required for this fixture, and is in the shape of an angle-plate with projecting bosses at the front and back at *B B* as surfacing-points for the work, and four projecting lugs on the face, of which *E E* are for the locating-points and *D D* for the fastening screws. For clamping the work in position a device is used which allows the work to be fastened or removed with the greatest rapidity. It is shown clearly in the sectional view of the fixture, and consists of a stud *M* of tool steel, which is turned to fit nicely the hole *I* in the work and *L* in the fixture. It is of the same diameter for its entire length and is threaded at the end *P* for the nut *S* and reduced as shown in *N* to admit the clamping-washer *Q*. This washer is of tool steel and is knurled on the outside so it can be easily removed, and has a section cut out as


A
TOP VIEW
C
P
S
B
T
B
H
g
g
Q
O
H
g
S
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B
Q
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L
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D
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U
SECTIONAL VIEW, LOOKING AT LEFT END OF FRONT VIEW SHOWN BELOW

FIG. 146.

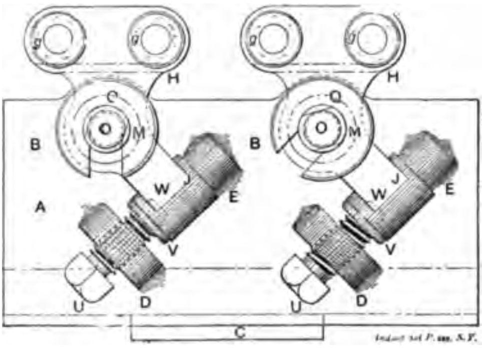

FIG. 147.

shown, for slipping it into the reduced channel *N* of the stud *M*. The locating-faces of the lugs *E E* are faced at right angles with the stud *N*, so that when the faced portion *J* of the work is forced against the locating-face it will rest perfectly flat and bear all over. The fastening-screws *U U* are reduced at the ends *W W*, ending in a square for the washers *V V*. The head of the clamping-stud *M* is milled with a flat on two sides for a wrench.

When in use, the fixture is clamped to the miller-table with the tongue *C* in the central slot. The nuts *P* of the clamping-studs are then loosened, the work slipped on as shown, the clamping-washer *Q Q* located, and the nuts *P* tightened by using wrenches on them and on the end *O O* of the studs. The work is then forced against the locating-lugs *E E* by the set-screws *U U* and milled, as shown, by setting a pair of straddle-mills for the proper depth of cut and clamping the cross-feed of the miller-table. To remove the work all that is required is to loosen the set-screw *U U* and the nuts *P*, slip off the washers *Q Q*, and remove the work. The rapidity with which this fixture can be operated and the perfect interchangeability of the work produced is surprising. The device shown for clamping the work is far superior to the usual methods adopted.

INDEXING MILLING FIXTURES FOR LAST TWO PIECES.

As there are a large variety of circular-shaped machine parts to be milled at different points regularly spaced, I show in the last two illustrations two types of indexing milling fixtures in which simple means are used for the attainment of the results indicated in the sketches of pieces shown in Figs. 148 and 149. The first of the two fixtures, the one shown in two views in Fig. 150, is used for milling the six equally spaced channels *M* in the disk, Fig. 148. The castings for these parts are finished all over in the turret lathe to the shape shown, and are then milled two at a time on the fixture, Fig. 150. The illustrations show a plan and cross-section view respectively; as the design and method of construction can be understood from them, very little description is necessary. *A* is the fixture proper, the work being located centrally on the studs *E E*, which are let into the base and located for height on the faced surfaces *C C* as shown in the cross-section. The holes in which the studs *E E* are located are bored sufficiently large to give clearance for the hubs of the work, as shown at *D*. The high projecting lugs *B B B B* are surfaced so as to allow the clamps *N N N N*, two to each part, to clamp the work securely. The indexing device is shown in the plan view and is self-explanatory. The projecting lug at the right end of the work has a slot milled through it in a central line with the central locating-studs *E E* and to the depth required, thus serving as a gauge for the depth of cut.

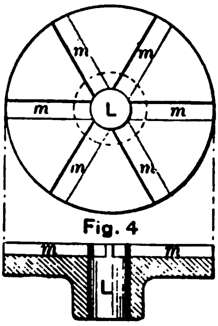

FIG. 148.

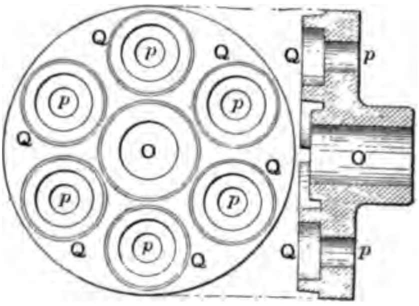

FIG. 149.

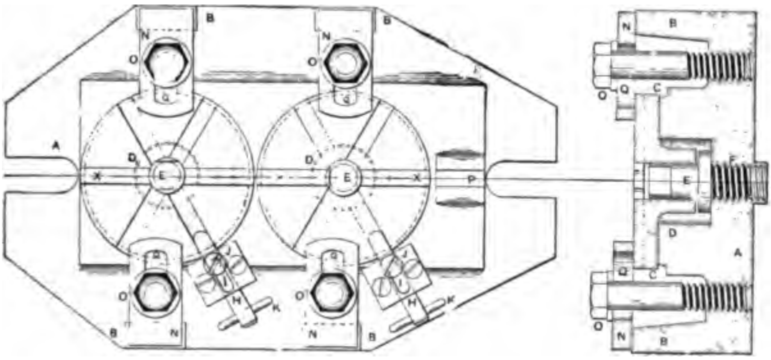

FIG. 150.

When in use the work is located and fastened as shown, only that the indexing-pins are out. A cut is then taken down through both parts, as shown by the arrows, to *X X*. The table is then run back, the clamps slacked, and the work moved until the index-pins *H H* enter the channels just milled. Tightening the screw *J* of each to hold it securely, the cutter is run through again and the operation repeated. The work is then removed by loosening the clamp-bolts *O* and sliding the clamp back; provision being made for this by slotting the bolt-holes of the clamps, as shown at *Q Q* in the cross-section. By changing the location of the indexing device, work may be milled with any number of slots or grooves; in fact, there is an inexhaustible variety of work for which fixtures of this design can be adopted with the best results.

Fig. 151 shows two views of a fixture, the use of which demonstrates how work usually produced in jigs on the drill-press may be machined in a better manner by the use of simple fixtures on the milling-machine. The fixture is used for counterboring and facing the six bosses of the spindle-disk casting shown in two views in Fig. 149. The points previously machined are the hole *C*, the six holes marked *P*, and the two hubs, all being finished to interchange. The fixture consists of the angle-plate *A*, which has a projecting hub on either side at *D* and *B*, and the central locating-stud and the indexing pin *O*. After the angle plate is planed on the bottom it is fastened to

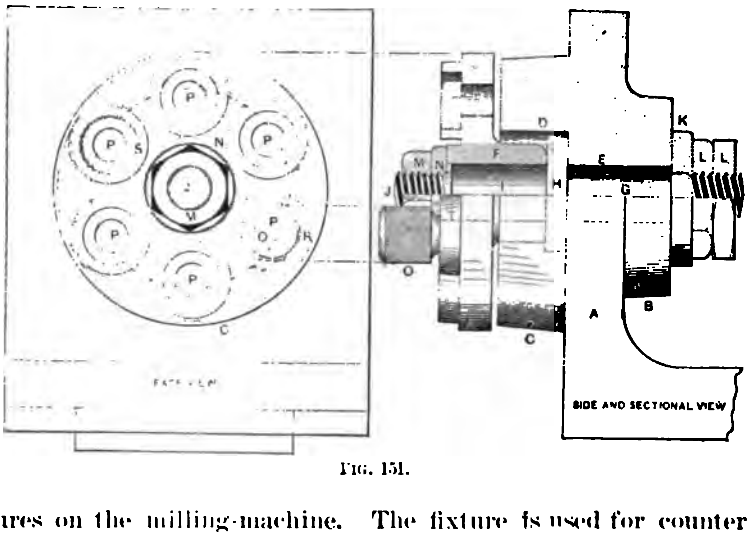

Fig. 151.

the lathe face-plate, and the hub *D* faced. A hole is then bored straight through the centre of the hubs and reamed to size, and counterbored to the diameter and depth shown in the sectional view, for clearance for the hub of the work. It is then transferred to the planer, where the hub *B* is faced and the channel let in for the tongue. The central locating-stud is then finished so as to shoulder at *H*, and reduced and threaded at the back end for the washer *K* and the jam-nuts *L L*, so as to revolve freely without play within the fixture. The device is now drilled for the two hardened steel bushings, one at *R* for the index-pin *O* and one diametrically opposite at *S*. To properly locate these bushings, the work is fastened on the central stud *I* and the hole for the index-pin bushing *R* is finished, first by drilling through one of the holes *P* in the work, which is then removed and the hole counterbored to admit the bushing *R*, as shown by the dotted lines. The hole through the bushing is lapped to exactly the same diameter as the six reamed holes *P* in the work. The index-pin *O* is then made of tools teel—the head being knurled as shown—then hardened and ground to fit snugly within the reamed holes *P* in the work and the bushing *R* in the fixture, being located by entering index-pin *O* through one of the holes *P* and into the bushing *R*; the hole for bushing *S* is finished, and the bushing entered in the same manner as the other.

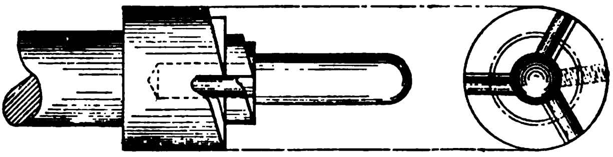

FIG. 152.

To operate the fixture the work is fastened as shown, and the counterbore located in a taper-sleeve in the miller-spindle. The longitudinal and cross-feeds of the table are then manipulated until the lead or supporting stud of the counterbore, Fig. 152, is in line with and can be entered into the bushing *S*. The work is then fed against the cutter until the required amount of stock has been removed, and the graduated dial on the cross-feed screw set at *O*. The table is then moved back, index-pin *O* removed, and the work revolved one space or until the next hole *P* is in line with the bushing *R*. The index-pin is then re-entered and the operation of counterboring and facing repeated, and so on until all six of the bosses have been machined in repetition.

CHAPTER XI.

Miscellaneous Milling Fixtures, and Special Tools for Similar Work.

A MILLING FIXTURE FOR DRILL-PRESS TABLES.

In the machining of tables for three- and four-spindle sensitive drill-presses, one fixture is worthy of interest, as it is both simple and effective for the accomplishment of the work desired. It is also suggestive for other work. The fixture is used for milling the dovetail in the table to fit the slide-surface of the base or lower column, and is shown in two views in Figs. 153–154.

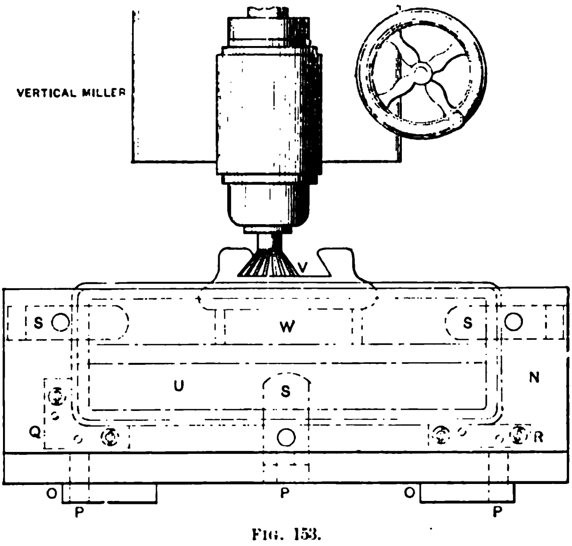

FIG. 153.

It is used, as shown, in the vertical milling-machine. The table-surfaces of the castings were first planed up, after which they were ready to be milled. The fixture consisted of one casting *N* in the shape of an angle-plate. This casting was first planed on the bottom and the tongues *O O* fitted to the slot in the miller-table. A cut was then taken off the face, getting it as true and smooth as possible, as the face of the table located against this surface. The two gauge-pieces *Q* and *R*, respectively, were worked out and fastened to the angle-plate with dowel-pins and screws, so they would serve as locating-points for the edges and face of the table. Three holes *P P P* were drilled in the base of the angle-plate, as shown, for the bolts

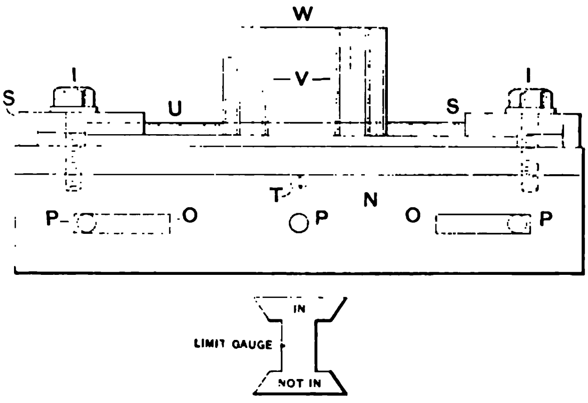

FIG. 154.

used in fastening it to the milling-machine table. Holes were also drilled and tapped in the face for the strap-screws *T T T*. Three straps were then made of machine steel and bent at right angles at one end, finishing them so as to be in the position shown when clamping the table.

The fixture was then set up and clamped to the miller-table, as in the position shown in the top view, and a table ready to be milled stripped to it as shown, resting and being located on the top pieces *Q* and *R* respectively. A screw-jack was then used to brace the extension part of the table at *W*, thereby taking up the downward strain on the table while the dovetail was being milled. The milling was then finished in two cuts, as shown at *N* in the upper view, milling it to fit the limit-gauge shown at the bottom.

The use of this fixture gives a practical illustration of one of the various kinds of work for which the vertical milling-machine is adaptable, as the operation shown can be accomplished in one quarter the time which it would take to do on the planer, or on the regular milling-machine—where, in milling the dovetail, the table would be strapped to the miller-table, which would have to be raised and lowered by hand while milling, which is both hard on the operator and on the machine as well; as will be at once understood.

JIG FOR MILLING DRILL-PRESS SPINDLE-HEADS.

The jigs described and shown in the following were used for milling and boring drill-press spindle-heads manufactured by the interchangeable system, and are both reliable and cheap in design and construction.

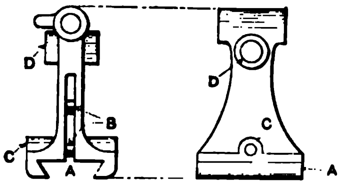

FIG. 155.

The spindle-head is shown in two views in Fig. 155, and a slight description will tend to the intelligent understanding of the requirements and construction of the jigs. The operations on the head consisted of, first, the milling of the dovetailed *A* to fit the column of the drill-press; then the cutting out of the two lugs *B*, thereby allowing sufficient spring in the spindle-head to tighten it to the column. The hole is then drilled at *C* for the clamping-lever. After this is done, the hole *D* is bored and finished. This hole must be accurately located, as the pinion, when inserted, must mesh accurately with the rack on the spindle, and in order for the heads to interchange the jigs must be accurately constructed. When casting the heads, the holes for the spindle and pinion are cored sufficiently small to allow

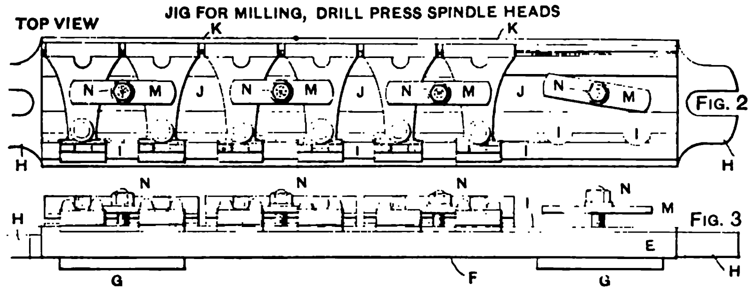

FIG. 156.

of the holes being finished to size, in case of a slight variation in the location of the holes when cored in the casting.

The jig used for milling the dovetail *A* in the head is shown in three views in Figs. 156 and 157 respectively, and is very simple in both design and construction. It consists of, first, a large flat casting *E*, for which a pattern of the size and shape shown was first made, and stock left sufficient at all locating-points to allow of finishing. After a casting was secured, it was first set up on the planer and the back planed and the tongues *G G* fitted to the central slot of the table of the large milling-machine. It was then placed on the table of this milling-machine, and clamped to the table at each end, *H H*. By viewing the cross-section shown in Fig. 157 it will be seen that the head is located at three points *I*, *J*, and *K*. The point *I* is milled out, as shown, to a radius approximately the same as that portion of the head which rests at that point, as shown. The points *J* and *K* are then milled so that the head will rest perfectly parallel on the jig. In locating castings of the kind shown, the clamping portion must be located at the strongest point, especially in this case, as the milling is finished in two cuts, which are very heavy cuts. As will be seen, this jig is made to accommodate eight heads, and for clamping these, four studs and straps are required; each one clamping two heads, as shown at *M M M M*. The studs are of machine steel, turned and threaded at each end and screwed tightly into holes drilled in the jig. As shown, the straps are of $\frac{3}{8}$ inch flat machine steel, cut off the proper length and dressed at each end at the grinder. The nuts *H* are faced upon one side and case-hardened. When all parts are assembled as shown, and the eight heads strapped and located in position, an angular end-mill, screwed and fastened on to the screw-arbor, is used for milling them. For gauging the depth of cut, a double ended gauge of $\frac{1}{4}$-inch tool steel is used, one end to go in and the other end not to go in. For gauging the distance from the centre of the spindle hole to the faces of the cutter, a button-gauge is used, the bottom fitting the spindle hole (which

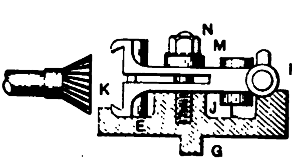

FIG. 157.

is rough) freely, and the piece of steel in which it is fastened resting on the table of the miller. The distance from the cutter to the other end of the gauge being correct, the work is fed in until the face of the cutter just touches the gauge; the cross-slide of the table is then clamped, and the table is raised or lowered, as may be required, until the edge of the cutter rests on a slight projection on the end of the gauge. This is for locating the cut approximately central with the spindle hole. The miller is then started, and the cutter allowed to run through the entire eight heads. The table is then fed back to the starting point and raised a sufficient number of thousands until the small gauge will just go in. The cut is then started and run through, then the heads are removed and another eight located and clamped. The operation is then repeated.

MACHINING DRILL COLUMNS.

The tools here shown were designed by the author and used for machining the upper columns of small, one-spindle drill-presses. The column is shown in position on the fixtures. The points machined are the finishing of the slide-surface *A A* for the adjustable spindle-head; the milling of the base *M* and of the back *P*, as shown; and, lastly, the boring of the hole for

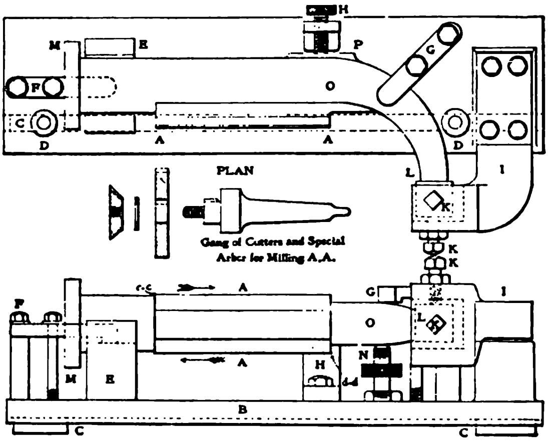

FIG. 158.

the spindle through the column at *L* and through the spindle-head.

The milling of the slide-surface is done first in order to have a reliable surface by which to locate for the following operations. The body of the fixture is a long casting, *B*, with a high projection at each end, the one at *E* being a "*V*" for the body of the column, and the one at the other end flat and square with the base, for the head-supporting bracket *I*. This bracket is of cast-iron, cored out at *J* so that the head of the column *L* will enter it, the inner side of *J* being open so as to allow of this. The bracket is fastened to the body casting by four cap-screws. A feather *C* is let into each end in a channel in the base to locate it in the slot of the miller-table, and it is fastened by bolts through the holes at *D D*. Two clamps at *F* and *G* are used to fasten the work; *F* being nearly over the vertical adjusting-screw *N*. A knurled head-screw at *H* forces the head *L* against the locating set-screw *K* in the face of the bracket *I* and the two other set-screws *K* act vertically as locating- and fastening-screws.

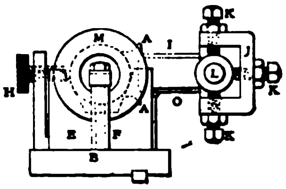

FIG. 159.

For the milling, a gang of cutters and a special arbor of the shape shown are used, the angle or first cutter being threaded with a left-hand thread to screw onto the arbor and force the other two cutters tightly together. The narrow cutter is to finish a flat along the extreme edge of the milled surface, and the large one is for milling the face. The last two cutters are keyed to the arbor.

The fixture is first bolted to the miller-table, and the work is fastened upon it, adjusting all locating-screws so that approximately the same amount of stock can be removed from all parts. As the variation in the castings is very little, if the first column has been machined correctly all the others will be. A gauge is used to set the gang of mills. The work is moved up to the cutters until the face-cutter is removing the required amount of stock and the angle-cutter is touching the gauge. When the top is finished, the table is raised and the under side is finished, starting at D D. Before this fixture was designed, the finishing of the slide A A was done on the planer; but by this arrangement the same results were accomplished in one-third the time and to a far greater degree of uniformity.

For facing the base M and the surface P the fixture shown in Figs. 160–161 was used. This was made for three columns, only one of which is shown. The dovetailed slide-surface previously machined is utilized for locating and fastening the columns. The fixture consists of one heavy body casting, with three standards on which the work is fastened. The locating-surfaces at F F F, respectively, are finished on the planer, one side at E with a dovetail at the same angle as that of the machined surface. Two angular-faced clamps G G, with clamp-screws H, are used for fastening each column. Two straps H H are also used; although they are not absolutely necessary.

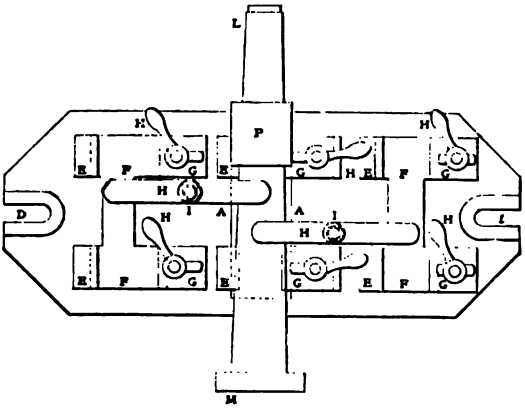

FIG. 160.

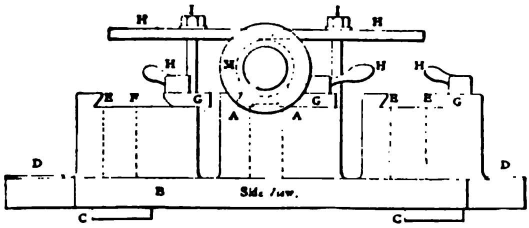

FIG. 161.

The base *M* is finished first, doing the entire number of castings. They are then reversed on the fixture and the backs *P* are faced with an inserted tooth-face milling-cutter, which is fastened in the vertical attachment. The same cutter is used for facing the bases of the columns.

The boring-fixture is shown in Figs. 162–163, in the side view of which the work is shown in position, with the spindle-head attached to the slide-surface, ready to be bored. The boring and finishing of the spindle hole in the head *L* of the column and in the spindle-head at one and the same time is necessary in order to insure the alignment of those holes. This fixture is rather more intricate and expensive than the two preceding; but the cost was approved by the result.

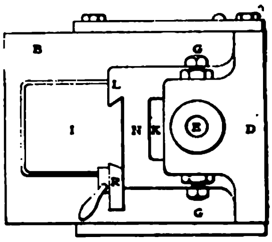

FIG. 162.

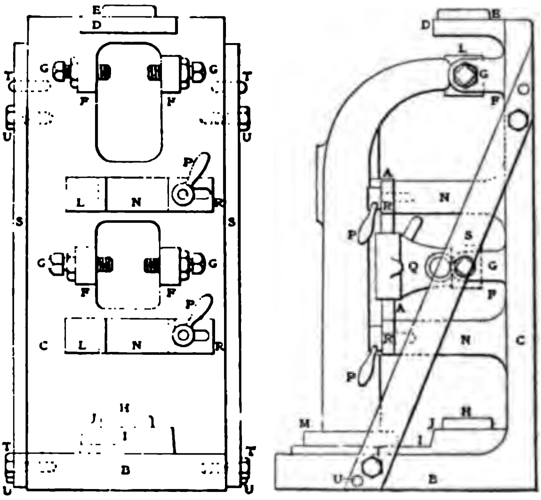

FIG. 163.

The fixture is in the form of a tall angle-plate, with two standards *N* projecting from the inside of *C* for the locating- and fastening-points. These standards are cored at *K*, as shown in the end view, to clear the boring-bar. Bevel-faced clamps *R R*, with clamp-screws *P P*, secure the work. There were two bushings, one at the top in *D* at *E*, and the other in the base *J* at *H*. The holes for these bushings were cored small in the fixture when cast, and were bred to finish size on the large drill-press on which the fixture was to be used. Before boring and finishing these holes, the other locating- and lining-points on the fixture were finished, and the piece was strengthened by fastening two wide and stiff machine-steel straps at the sides, as shown at *S S*. These straps strengthened the fixture considerably and insured its rigidity.

The bushings *E* and *H* were of tool steel, hardened and lapped to a good fit on the boring-bar, and then ground on the outside and forced into their respective holes. There were four lugs *F* with hardened set-screws *G* and check-nuts to resist side-thrust when boring the holes in *L* and *Q*. Large openings in the upright at *b b* and *c c* were convenient for inserting, fastening, and removing the cutters from the boring-bar.

The fixture rests on the base *B* on the table of the large drill-press, and the work is fastened as shown. The boring-bar is then slipped down through the bushings, and the table of the drill-press swung around until the shank of the bar can be driven up into the drill-spindle. The roughing-cutters are fastened in the bar and fed down through the holes. The bar is then raised; the roughing-cutters are removed; a finishing set is substituted, and the holes then finished.

The boring fixture here shown was used only for machining single-spindle columns; for the two, three, four, five, and six-spindle frames a special self-driven machine, that might be set to bore two columns at once, was used. In this machine the work was located and fastened upon it in the same way as here shown, the only difference being in the driving of the boring-bars or cutter-spindles by bevel-gears, and feeding them through the holes in the work by a pinion and rack, in relatively the same manner as on a self-feeding drill-press.

CHIEF FACTOR IN MACHINE MANUFACTURING.

One of the chief factors in modern manufacturing of machine parts by the interchangeable system is the selection of the proper machines and tools for the accomplishing of the results desired; those that will allow of the rapid machining of the work are, of course, the ones to use. It is a common sight in a great many manufacturing machine-shops to see work being laboriously performed by the use of inadaptable machines and tools, which could, by the use of a machine more adaptable for it, be accomplished with ease and expediency. In fact, I have often seen machines standing idle while the work which should have been machined in them was being done in others which were not at all adapted for it. Thus we learn that in order to get the maximum of production from the minimum of labor we must always consider and select the machines which are the best adapted for the work; as well as pay attention to the designing and construction of the tools and fixtures for the operations necessary to finish it.

CHAPTER XII.

Special Tools, Fixtures and Devices for Machining Repetition Parts in the Turret-Lateh.

THE USE OF SPECIAL FIXTURES IN THE TURRET-LATHE.

IF there is one type of machine tool that, more than any other, has taxed the ingenuity of the designer and the skill of the tool-maker to keep it supplied with work, it is the turret-lathe; as the numberless varieties and classes of work which this great factor in modern manufacturing is capable of handling are enormous. When I state the above I do not refer to the commoner classes of work produced in this machine, as the tools for their repetition and duplication are sufficiently well known and understood to make their use universal, and descriptions of them would be superfluous. I refer to the special, odd, and brain-racking jobs that are constantly coming along, for which the ever-resourceful tool-maker is required to construct tools so that the parts may be turned out rapidly and accurately.

For the production of parts in large quantities in repetition, which can be finished by turning, boring, or facing, no other machine tool, when equipped with suitable tools, offers the advantages or is better suited than the turret-lathe, or its elder brother, the screw-machine. To faciliate the production and the efficiency of the machines, and reduce the responsibility of their operators to the minimum, thousands of tool-makers throughout the country are constantly engaged in constructng devices, fixtures, tools, and arrangements. It is with these classes of tools that I propose to deal in this and the following chapter; devoting this one to the use of special tools in the turret-lathe and the next to the use of similar tools in the screw-machine.

It will not be necessary to go into detail in regard to the standard tools used in connection with the various devices and arrangements shown, as their use is well understood, and it would be digressing unnecessarily to treat them or the machines in detail. In regard to the special tools, however, too much cannot be written.

The variety of the tools shown and the description of their construction and use will warrant a careful perusal by the reader; as they will be the means of suggesting modifications of the designs which can be embodied in tools for work other than that shown in connection with them. Tools of these types are great reducers of cost of production; and the ability to devise and install them successfully is an enviable capability of the modern tool-maker.

ATTACHMENT FOR FORMING IRREGULAR PIECES FROM THE BAR.

The turret-lathe fixture shown in the accompanying engravings is for forming pieces of irregular outline from the bar. It is adapted for work having considerable stock to be removed, and will duplicate the pieces very accurately and leave the finished surface smooth and free from tool marks. As it is always

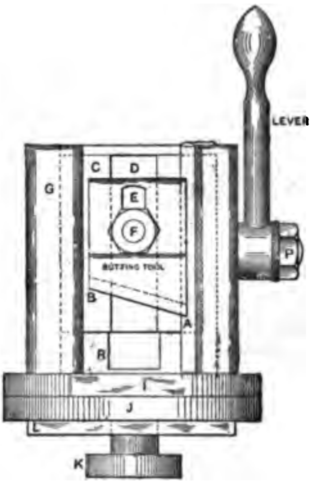

FIG. 164.

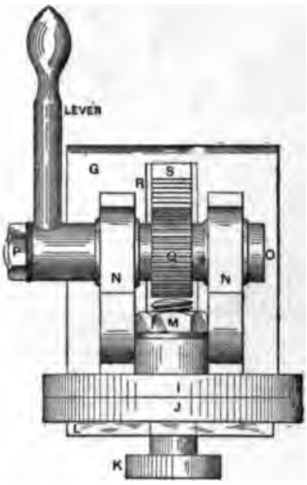

FIG. 165,

ready for use and can be fastened in place on the turret-lathe and set for the results desired in short order, it should find a place in all shops where the value of the turret-lathe is appreciated.

Figs. 164–165 are front and back views of the fixture complete, while Fig. 166 is a side view, as the fixture appears when bolted to the back of a turret-lathe cross-slide. The latter view also shows the manner in which the cutting-tool is presented to the work.

The fixture proper consists of two main parts of cast-iron, the round base *J* and the body casting *I*, constructed to swivel on it.

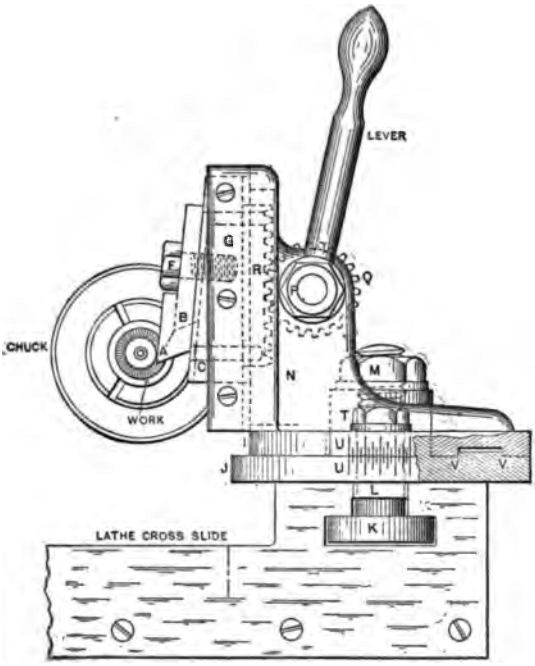

FIG. 166.

The front *G* of the body casting is dovetailed and has a rib *H* for the steel slide *C*. The ribs *N N* act as strengthening ribs for the front and also as bearings for the pinion and lever-stud *O*. The steel slide *C* and an oblong opening *R* allow the rack to project through the front *C* and mesh with pinion *Q*. This allows slide *C* to be moved up or down by the lever at the side. The pinion, stud *Q* is of tool steel and has a large head at one end and is reduced and threaded on the other for the lever and fastening-nut *P*. The lever and pinion are keyed to the stud.

The front or face of the steel slide *C* is finished on an incline at approximately the angle that would be adopted for the front clearance of a lathe-tool. This is done so as to avoid having to give this clearance to the cutting-tool, which is fastened to the face of the slide, and requires clearance on the bottom only.

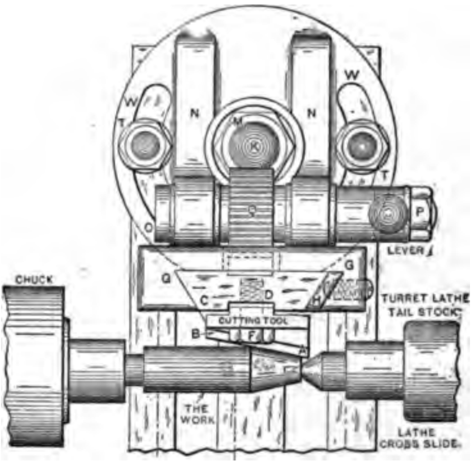

FIG. 167.

The cutting-tool, as shown in the side and front views, is located within a smaller channel in the face of the steel slide *C*, at *D*, and is held by means of the large cap-screw *F*. The cutting-edge of the tool is sheared off at the angle shown in the front view, from *A* to *B*, so that it will remove the metal from the work progressively.

The circular portions of the two main castings, Fig. 164, are so constructed that the body of the tool can be swiveled, there being graduations at *U U* to enable it to be set accurately at the desired angle with the work. The base *J* is provided with a tongue *L* which fits nicely in the slot for the tool-post in the turret-lathe cross-slide. The main casting *I* is hollow in the center to allow a centre hub of the base to project up through it. The bolt *K*, by which the base is secured to the cross-slide, passes up through this hub and thus it is not necessary to loosen the base when swiveling the body casting or tool-head. To set the tool-head the two nuts *T T* at the base studs are loosened, and the head graduations set to the angle desired. The nuts are then fastened, and the head is rigidly held in position. The manner in which the two castings are finished so as to locate true with each other and swivel, is shown at *V V* in Fig. 166.

As a practical illustration of the manner in which the fixture is used, there is shown in Fig. 167 a plan view of it as located and fastened to the lathe cross-slide, with the cutting-tool in position for finishing from bar stock the taper end of a mild steel tool-post. For this work a tail-stock, equipped with centre, replaces the turret usually employed and supports the end of the piece being formed and also sets the gauge for length.

In machining the part shown in Fig. 168, the stock is fed out the required distance, and the spring-chuck jammed. The tail-centre, which is very hard, enters the bar far enough to support it. The handle of the fixture is then grasped by the operator and pulled downward until the lowest point of the cutting-tool at *A* is somewhat near the centre of the revolving stock. The cross-slide of the lathe is then fed forward, and the tool commences to cut until the slide stops against the stop-screw and the edge of the tool has removed considerable stock. The slide is now held securely against the stop-screw by the operator pressing down hard on the cross-slide lever; then with his right hand he pulls down on the tool-head lever, thereby feeding the cutting-tool downward, and the stock is gradually removed by the shearing cut of the tool, and the bar is finished, as shown. As each portion of the tool's cutting-edge removes the metal, it passes below the centre of the bar and ceases to cut, so there is

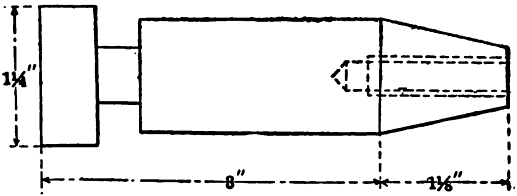

FIG. 168.

only a narrow surface of cutting-edge of the tool removing metal at the one time. The machining of the work is thereby progressive; there is no tendency to chatter or mark the work; and by having a good stream of oil constantly running on the work, a fine, smoothly finished surface is the result. As soon as the entire cutting-edge of the tool has passed below the cenrte of the bar, the lathe cross-slide is fed back to its former position, and the cutting-tool raised for the next piece. In order to produce the best results, the cutting-edges of the tool should be left quite hard, and be oil-stoned to a perfectly straight and keen edge. The amount of clearance and shear has also considerable effect on the results, and must be determined by the quality and nature of the material which it is desired to machine.

In Fig. 169 is an illustration of a piece of work, the taper surface *G* of which is finished by the use of the special fixture.

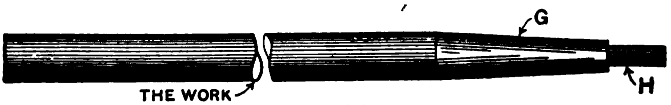

FIG. 169.

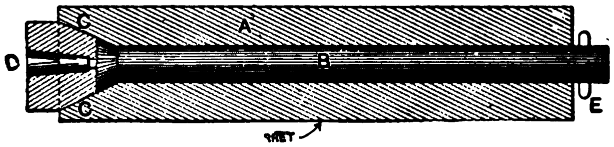

FIG. 170.

In Fig. 170 is shown a special turret-tool used for supporting the smaller tapered end *H* while the other part is being finished. The stock machined was a $\frac{3}{8}$-inch drill-rod, and the long taper surface was required to be finished as smooth and clean as possible, and slight changes were made in the tool slide to accomplish these desired results. The slide *C* of the fixture was replaced with another that differed from the first only in that the face was left straight and at a right angle with the cross-slide, instead of being inclined for back clearance. Thus, when the edge of the cutting-tool passed by the centre of the stock, the portion machined would rub against it, and with the stock rapidly rotating, the friction was sufficient to give quite a polish to the machined surface.

In Figs. 172 and 173 are shown two samples of work, the formed surfaces of which were machined by the use of the fixture here shown, and in Fig. 171 is a sketch of one of the cutting-tools used for them, from which an idea of their construction may be gained.

The great saving in producing work of this class direct from bar stock, in preference to using separate castings, has made the turret-lathe as great a factor in the production of machine parts as the engine-lathe. For that reason any method or device which will add to the capacity of the machine and increase the sufficient of output should be adopted, and the fixture herein described is one which will do this. It can be easily adopted for work other than of the class shown, such as chandelier and electrical fixture work, where large quantities of ornamental knobs, joints, and various other parts are produced from large brass rods or bars; and, in fact, for producing shaped pieces from the bar of steel, brass, fibre, or hard rubber.

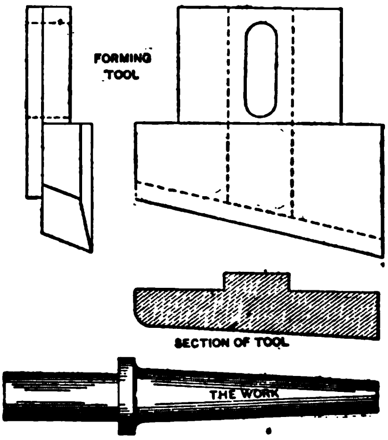

FIG. 171.

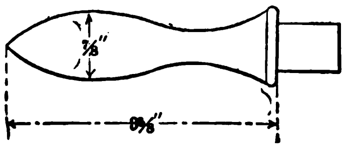

FIG. 172.

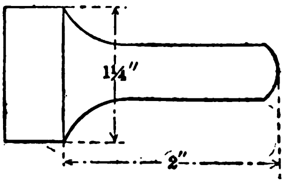

FIG. 173.

BOX-TOOL FOR THE TURRET-HEAD.

In Fig. 175 is shown the pinion as used in drill-press spindle-heads, and in Fig. 174 the tools used for the first operation. These pinions were of cold-rolled mild steel, and were roughed out and countered at each end in the turret-lathe. The box-tool shown in Fig. 174 and a cutting-off tool were all that were necessary for it. The box-tool is finished from a mild-steel forging, which is first centred, and the stem *E* turned to fit the hole in the turret, and both ends faced. It was then located on the head centre and set to run true in the steady rest, and the hole bored in the face for the bushing *G*, which was of tool steel, hardened and lapped to size, to fit the stock to be worked. The set-screw *L* holds it in position. A hole is then bored and reamed through the stem *E* for the centre-drill *K*, which is fastened within it by the headless screw *M*. Two cutting-tools, *I* and *J* respectively, are let into the box as in the position shown: one, *I*, for roughing, set slightly in advance of the other one, *J*, which finishes. These two tools are hardened, and drawn to a light-straw temper; a set-screw for each, on the side, holds them in position. When using the tool, the bar of stock is held in the spring-chuck, and the tools *I* and *J*, in the box-holder, set so as to rough down the stem *B* of the pinion-blank, Fig. 175, as shown, leaving enough stock to allow of a finishing

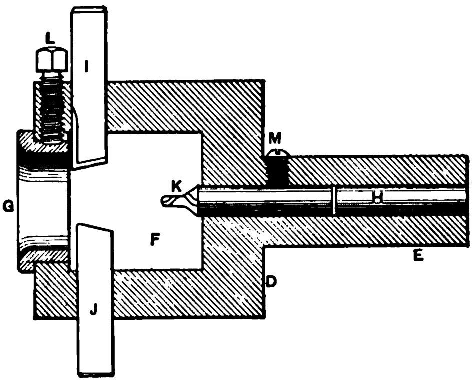

FIG. 174.

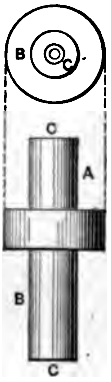

FIG. 175.

cut being taken in the lathe, and then grinding them to size in a Lanis grinder. The centre-drill *K* is set so as to centre the end of the stem at the same time. The use of the two cutters in the box-tool, as shown, acts very well, and reduces the time on the work considerably, removing the stock—as it does—all in one cut. The fastening of the centre-drill, K, as shown, also contributes to reducing the time, as well as centring the stem true.

TWO SPECIAL CHUCKS FOR THE TURRET-LATHE.

In Fig. 176 are shown two views of a special chuck used for boring and facing the hubs of cast bevel-gears. This chuck, together with the one shown in Fig. 178, is used for the machining of gears which are used in large quantities on cheap machines, and their use allows of the work being produced in a very rapid manner, and to the degree of accuracy required and as cheaply as possible. The cross-sectional view of this chuck with the work in position shows clearly the design and method of construction. The body *K* of the chuck is of cast-iron, and is bored out and threaded at the back to fit the spindle of the turret-lathe. It is then finished on the face and a clearance-hole bored at *L*, and the locating-seat *M M* for the gear-face fin-

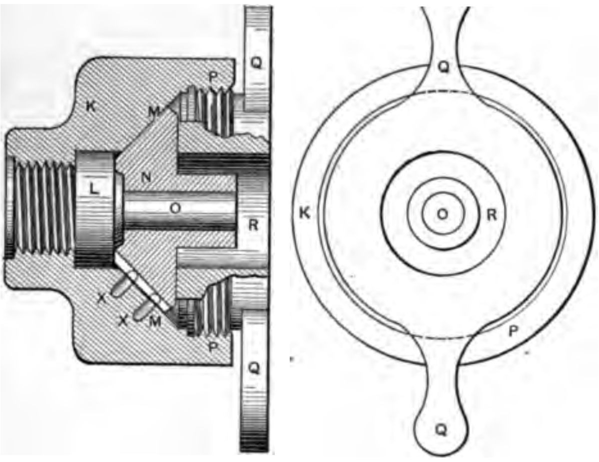

FIG. 176.

ished, as shown, by using the compound rest, and setting it over as required. The inside of the chuck is then threaded for the fastening-lid at *P P.* This lid is also of cast-iron, finished as shown, with two handles at *Q Q* and a clearance-hole *R* in the centre for the hub of the work. Six pins, two of which are shown at *X X,* serve to drive the work, by engaging the teeth of the gear as shown. When in use the chuck is screwed on to the spindle of the turret-lathe and the lid removed. The gear, as shown at *N,* is then placed within the chuck, with the driving-

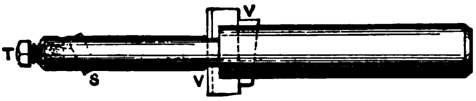

FIG. 177.

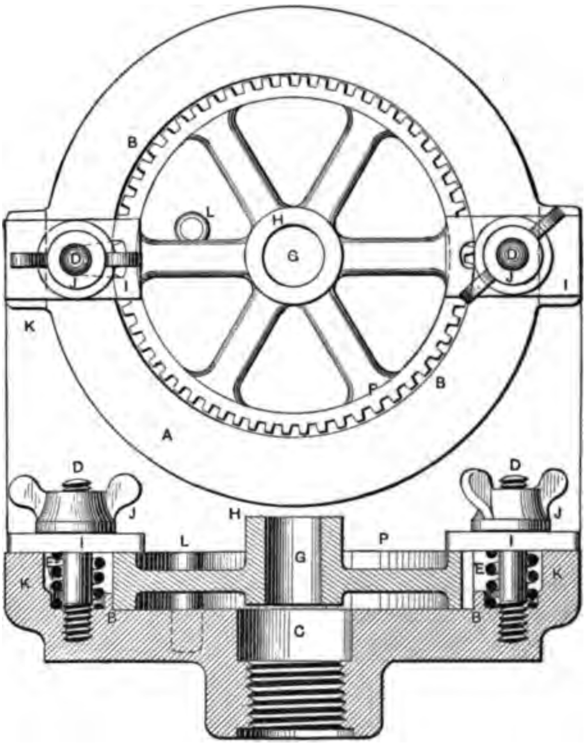

FIG. 178.

pins within the teeth. The lid is then screwed on and forces the bevel-face of the gear against the locating-surface *M M* of the chuck, truing it and holding it securely. The hole is then bored at *O*, and the hub faced by the use of the combination tool shown in Fig. 177. By the use of this chuck, the hole in the gear is bored and finished true with the gear-face, which in cast-iron gears is absolutely necessary, in order for the gears to run well when assembled.

The chuck shown in Fig. 178 is of a much simpler design and construction; but is just as useful and rapid in production for the class of work for which it is used as the other. It consists of one body casting *A* which is bored and threaded at back to fit the turret-lathe spindle, and bored on the face of the clearance-hole at *C* and at *B B* as a truing point for the gear-face of the work *F*. The work is fastened in position by the two clamps *I I*. The spring *E* around each of the clamp-studs contributes to the rapid locating of the work and its removal when finished. The work is driven by the stud steel pin *L* as shown, and can be located, fastened, and machined in a very rapid manner, as a turn of the thumb-nuts *J J* releases the clamps, which are raised above the work by the springs *E E*, and the work *C* can be slipped out and another gear located and fastened in its place in very short order. The hole is bored in these gears, and the hub faced by means of a tool similar to the one shown in Fig. 177. After boring the hole, it is finished to size by the usual chucking-reamer and finishing "floating" reamer, which insures the hole being round and true.

DETAIL SKETCHES OF TOOLS AND FIXTURES FOR MACHINING PULLEYS.

The set of tools of which sketches are here shown were designed by the author for finishing countershaft clutch-pulleys in the turret-lathe, and have been very successfully used for this purpose. It was desired to turn out the pulleys in large quantities, and to have the work accurately done, making them duplicates so far as their finished dimensions were concerned. The tools were so constructed that the pulleys could be finished complete at one setting.

The type of pulleys which this particular set of tools was designed to machine is shown in the two views in Fig. 179, and consists of a six-arm pulley of a common type. The points to be machined are as follows: The hole was to be bored and reamed and one end of the hub faced; the sides of the rim were to be faced, and an interior portion of the rim bored and finished on a very slight taper, as shown, for the friction or rubbing surface of the chuck; and, finally, the face of the pulley had to be crowned and finished.

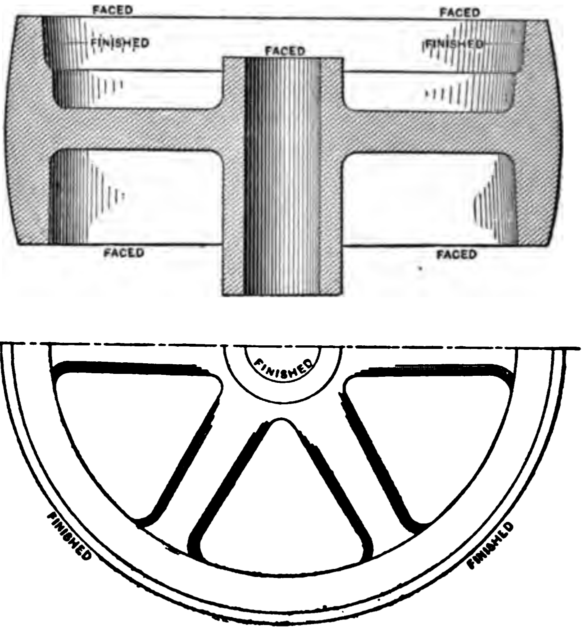

FIG. 179.

In order to accomplish all these operations at one handling of the piece, all the tools had to be specially constructed for the purpose. They consisted of a chuck for holding the work while being machined, a combination and boring hub-facing tool, a turret fixture for boring and finishing the clutch portion, and a special compound slide-rest, with cutting-tools at the back and front.

Two views of the chuck are shown in Figs. 180 and 184, and the several parts of the chuck appear in detail in the other figures. The chuck so holds the work that all points to be machined are easily accessible to the cutting-tools. There are nineteen parts in the chuck. The body is a forging of mild steel, and is bored and threaded at the back to fit the spindle of the turret-lathe. There are three projecting lugs or false jaws *I I I*, as shown, and the faces of these were turned off to form three

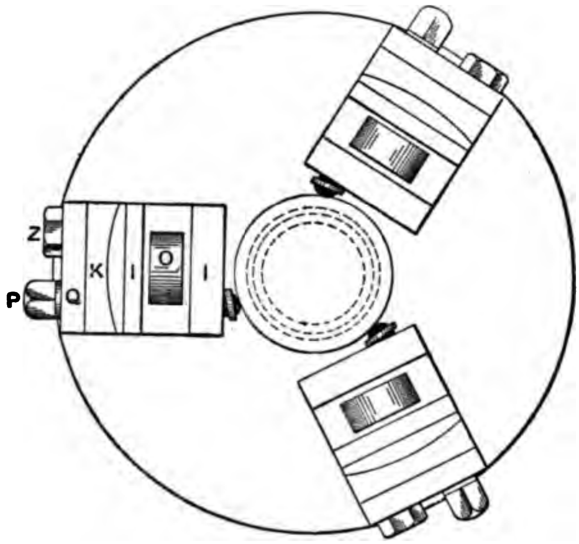

FIG. 180.

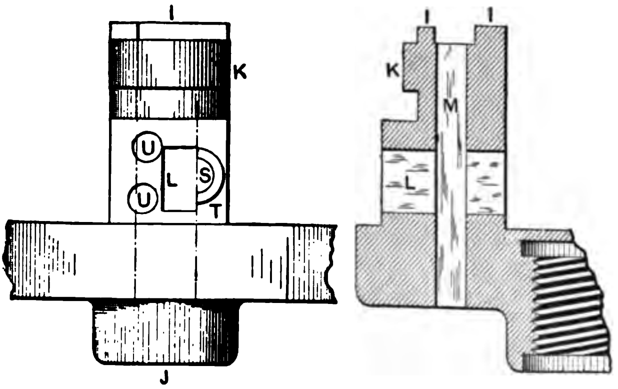

FIG. 181.

even supports for three of the pulley arms. The outside surfaces *K K* of the lugs were turned to a suitable diameter for the purpose of locating the pulley in a central position by means of the inside of the pulley rim, which comes in contact with these surfaces *K K* when the pulley is held in the chuck. The surfaces *K* and *I* of each lug, therefore, determine the position of

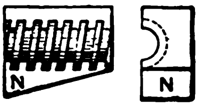

FIG. 182.

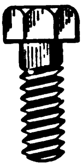

FIG. 183.

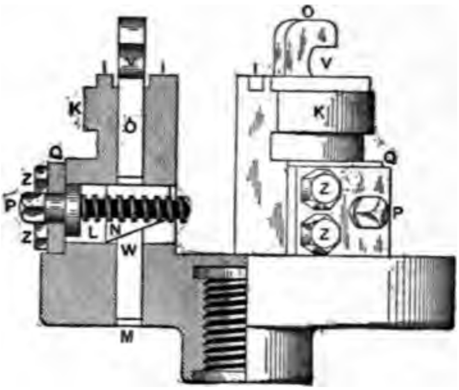

FIG. 184.

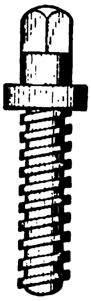

FIG. 185.

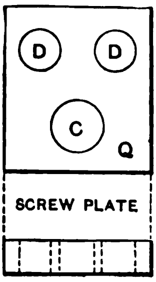

FIG. 186.

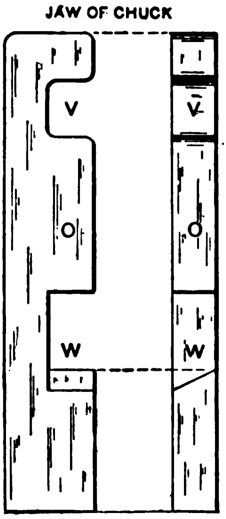

FIG. 187.

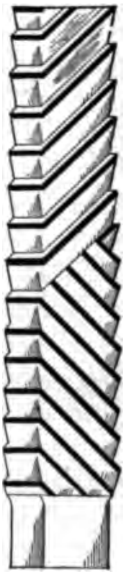

FIG. 188.

the pulley with sufficient accuracy for machining while the arms are clamped securely by the jaws *O O O*.

The construction and operation of the chuck will be clearly understood from the engravings, and it will be seen that the pulleys can be clamped in position or removed very readily. The three jaws *O O O* which grip the spokes of the pulley and draw them against the faces of the false jaws, are moved in or out, as required, by simply tightening or loosening the wedge-screw *P*, which raises or lowers the wedges *N*, as shown in the sectional view of Fig. 184. In making the chuck it is interesting to note that the finishing of the rectangular holes *L* and *M*, Fig. 181, in which slide the wedges *N* and jaws *O*, was accomplished by the use of broaches of the type shown in Fig. 188. For such work the broach should be constructed with very coarse teeth on the lower end to take out the bulk of the stock. It will be noticed that the teeth on the two ends of the broach are so inclined as to give shearing cuts in opposite directions, the object of this being to break off the chips as the broach passes through the work. The upper end of the broach is left perfectly straight for about two inches and serves as a "sizer." The broaching of the holes is accomplished by forcing the broach completely through them under the power-press. The machining of the other parts of the chuck presents no difficulties and will be understood by reference to the figures. All parts except the body of the chuck are of tool steel, and all wearing surfaces were hardened and tempered.

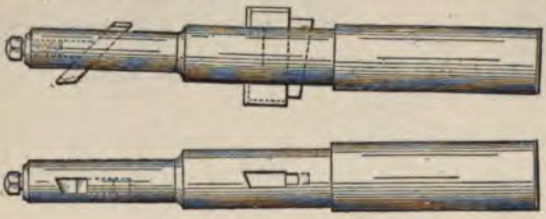

FIG. 189.

The combination boring and hub-facing tool-holder is shown in Fig. 189. After the hole in the pulley is bored and the hub faced by this tool, it is finished by the small chucking reamer and by a finishing reamer of the "floating" type, to insure the hole being true and round.

The special turret-tool for finishing the clutch portion of the pulley is shown in Fig. 190, and details of the parts in Figs. 191, 192, and 193. The three cutting-tools are held in dovetailed channels finished to an angle of three degrees with the centre line of the fixture, this being the angle of the chuck surface on the interior of the pulley rim. Having the grooves finished at this angle makes it easier to set the cutters correctly, and as the cutters are held by clamping they can be adjusted to remove the right amount of metal.

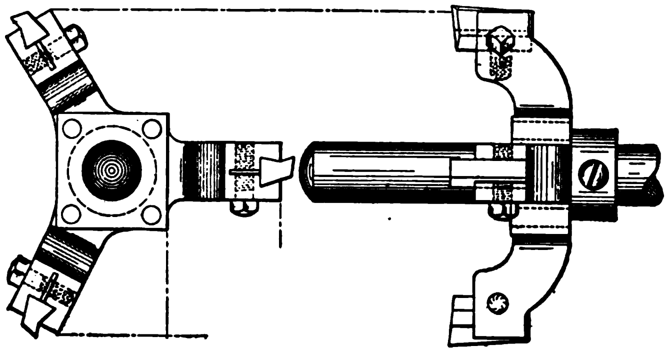

FIG. 190.

In Fig. 194 is a plan view of the special compound slide-rest, with the cutting-tools in position. This slide-rest consists of the main casting *A*, which is fitted to the carriage of the turret-lathe, replacing the cross-slide; of the compound rest *B* and *C*, in which the gashing- or roughing-tools are held; and of the face crowning- and finishing-tool fastened within the main casting *A* in a dovetailed groove at the back, as clearly indicated in Fig. 195. There are seven roughing-tools and two side tools, located in channels in the slide *C* and fastened by the set-screw in the strap *D*—the six short ones for gashing the scale and roughing off the face, and the other two for facing the sides of the pulley rim. The face crowning- and finishing-tool is located in such a

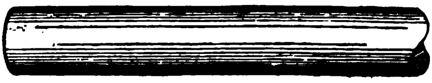

FIG. 191.

position in the body plate *A* that its cutting-edge will operate in a line tangent to the periphery of the pulley; and as the tool is designed to make a shearing cut, the metal is removed progressively from one side of the pulley to the other, thus reducing the strain and the tendency to chatter. A plan of the slide-rest is given in Fig. 194, and in Fig. 195 is the elevation, which also shows the manner of holding the pulley in the chuck.

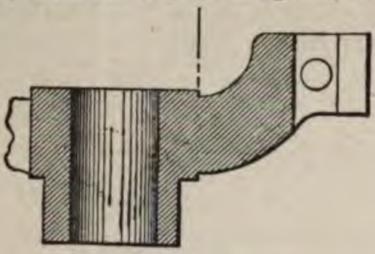
FIG. 192.

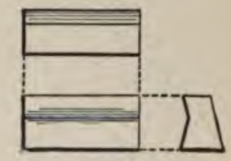
FIG. 193.

Referring to Fig. 195, it will be seen that the pulley is secured in the chuck by slipping the spokes into the notches of the jaws and tightening the wedge-screws *P* so as to draw the spokes tightly against the locating-faces, as shown. The hole in the pulley is then bored and the hub faced by the combination tool shown in Fig. 189, after which the clutch portion is finished by the fixture shown in Fig. 190, the leading stud supporting the work while it is being machined, and remaining in the hole until the pulley has been finished. The face gashing- or roughing-tools are next run in and fed sidewise about $\frac{3}{16}$-inch, thus removing all that is necessary to clean them up.

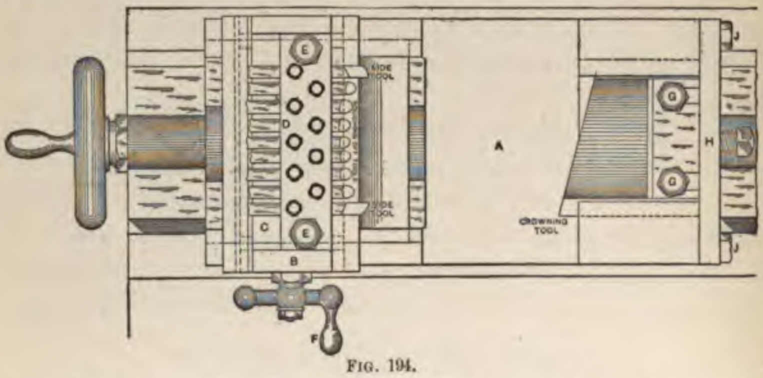

FIG. 194.

To crown and finish the pulley, the whole slide-rest is fed out by the cross-feed screw of the carriage until the entire cutting-edge of the crowning- and finishing-tool has passed beneath it and finished and sized it to the shape and size required. The use of this set of tools insures an exact duplication of the work produced at a low cost.

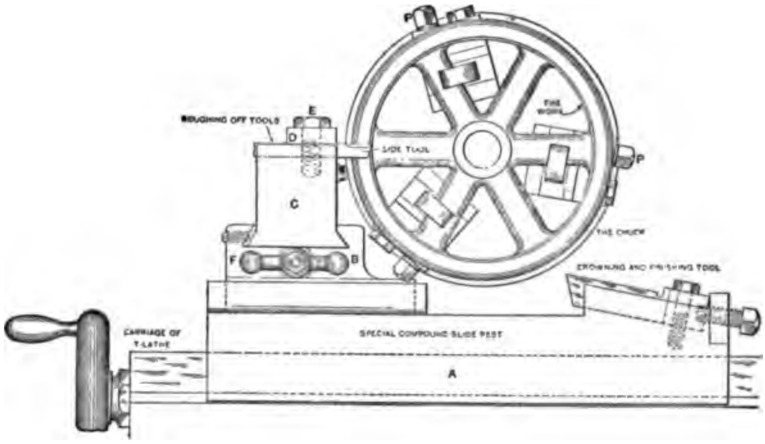

Fig. 195.

There is one thing that must not be lost sight of, when constructing a forming- and finishing-tool of the type shown here, for crowning the pulley: As the face or cutting-edge is finished and ground so as to take a shearing cut, and the tool is located in such a position in the main casting as to give it the required clearance-angle, the forming-face must be finished as shown at *B*, Fig. 196. As the tool is set at an angle with the face of the pulley, in order to produce the shape desired, one side must be considerably higher than the other, as at *B*. This should be figured out and a templet made, according to the degree of clearance given and the amount of shear to the cutting-face.

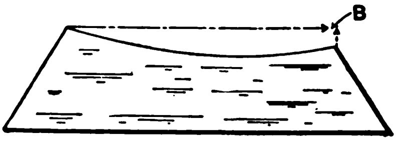

Fig. 196.

TOOLS FOR MACHINING A SPECIAL CASTING.

The hood-shaped casting shown in Fig. 197 formed part of an electrical appliance which was being manufactured in large numbers and, as it is a characteristic piece of duplicate work, the method employed in its production may prove of interest to my readers.

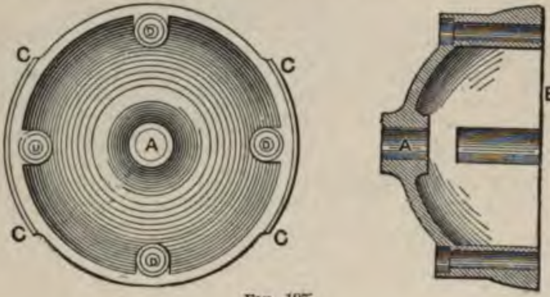

FIG. 197.

The operations necessary for machining this casting were, first, to drill and ream the $\frac{1}{2}$-inch hole *A;* second, face the base *B;* third, finish the circular portion *C C* given diameter and taper; and, finally, to drill the $\frac{1}{4}$-inch holes through the centre of each of the four parts *D.* The first and second operations were both performed in a turret-lathe with the casting held in a four-jaw chuck, as shown in Fig. 198. The hole *A* was first bored

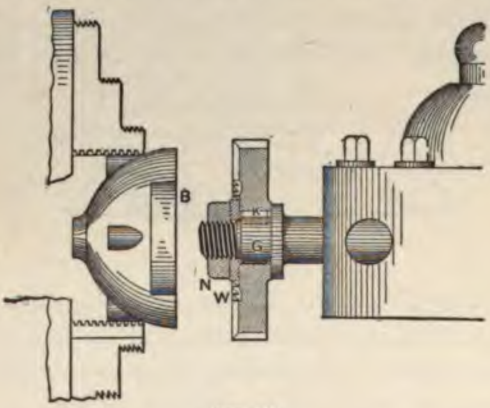

FIG. 198.

with the usual turret boring-tool and reamed to size with a "floating" reamer. The work was then driven slowly, by throwing in the back gears; and the second operation, that of facing the base *B* was performed by the use of a large face milling-cutter, placed on an arbor which was held in the turret-head, as shown in Fig. 198. This cutter was of the ordinary type of facing-cutter, except that the teeth, on the facing side, were staggered to prevent chatter. The cutter, which was driven by the key *K* was held in place on the arbor by the nut *N* and washer *W*.

With this cutter it was possible to machine a large number of castings before it required to be ground.

The third operation, that of finishing the circular taper surfaces *C C*, was accomplished as shown in Fig. 199 by the use of an end-mill in a universal milling-machine. The work was held on an arbor between the tail and dividing-head centres and the swivel carriage moved around until the table and arbor stood at the desired angle with the face of the milling-cutter. After setting the work so that the desired amount of stock would be removed, the cross-feed screw was clamped, and the work fed against the cutter by revolving the dividing-head by hand. For the last operation, that of drilling the holes *D D*, the jig shown in Fig. 200 was constructed. This jig was made in two parts, a

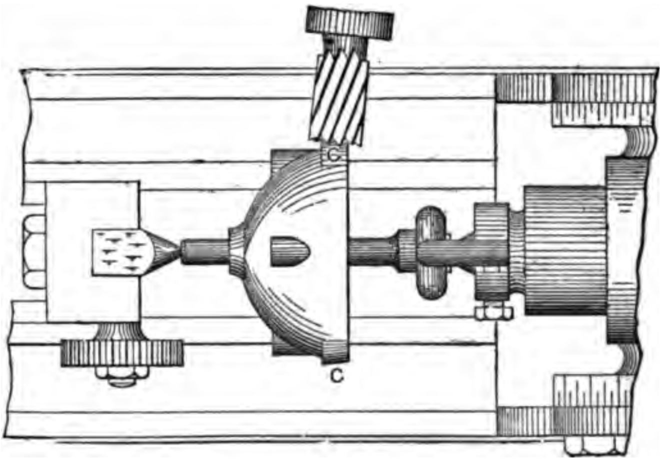

FIG. 199.

body casting in which the work was located, and a lid *W*, which was hinged at one side and carried the four tool-steel bushings *R R* by means of which the holes were located and drilled.

A hinged bolt and thumb-nut *Q* served to clamp the two parts together when the jig was in use.

The bottom of the body was bored out to correspond in taper and diameter with the taper surfaces of the work at *C C*. Extending inward from one side of this hole was a lug *K* in which was fitted the stop-pin *Z*. The stem of this pin, where it fitted the stop-lug, was eccentric with the body of the pin, so as to provide for adjustment, while the screw *J* locked the pin in place when the proper adjustment was attained.

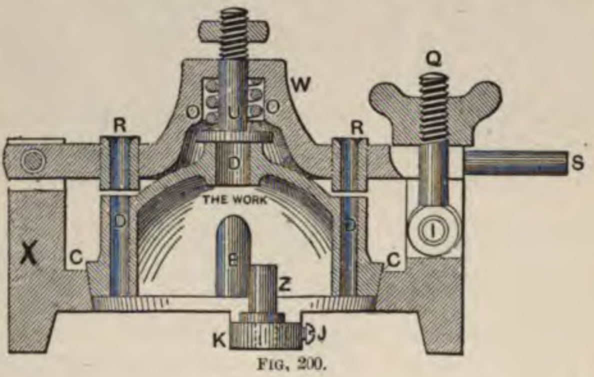

FIG. 200.

This pin was brought against one of the inner lugs of the castings, as at *E*, and thus located the lugs in the proper position to be drilled.

When in use the swinging clamp *Q* is released and the lid *W* thrown back. The work is then slipped into the body and located within the taper seat and against the stop-pin *Z*. The lid is then brought down by grasping the handle *S* and as the spring pad *U* strikes the work, the tension of the spring *O O* enables it to force it tightly down on the locating-seat. The lid is then held down on the body casting with one hand, while the swinging clamp is swung up and fastened with the other. The casting is then drilled through the bushings *R R*. One of the best features of the jig is the impossibility of the chips and dirt interfering with the accurate and positive locating of the work.

A MULTI-SPINDLE DRILLING AND TAPPING ATTACHMENT AND WORK FIXTURE.

The special multi-spindle drilling and tapping attachment and its work fixture, shown in the accompanying illustrations, were designed by the writer. The work shown in Fig. 201 is a circular casting with a large central hole and six small holes *a a*. It was for drilling and tapping these six holes that the attachment here shown was designed, and as it proved a great cost-reducer and allowed the required degree of interchangeability at the minimum of cost, its adaptability for a large variety of work is apparent. It also shows another use to which the ever handy —and often idle—turret-lathe may be put.

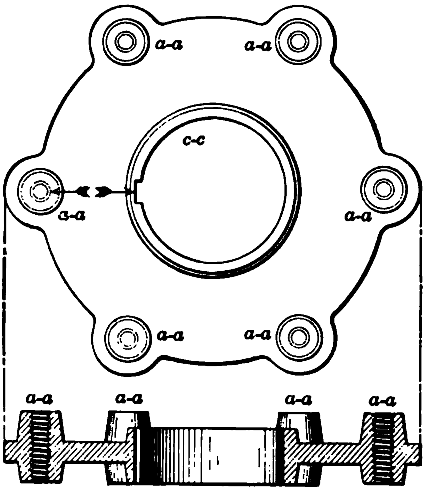

FIG. 201.

The six holes for the casting are equally divided around a circle concentric with the large hole *c c*, and are drilled entirely through the bosses. The large hole is bored and one side of the bosses faced in a preceding operation in the turret-lathe, and the keyway is let in so as to be in the same relative position to the bosses in all of the castings.

Fig. 202 shows, partly in section, the fixture complete and also several of the main parts. Fig. 203 is a plan, with the arrangement of the gears and their relative positions on the stationary spindle-disk. As shown in Fig. 202, the attachment consists of three main parts, of which *A* is the driver, *C* the stationary spindle and leading stud. The driver *A*, of cast-iron, was finished first, boring it out at the back and then threading it to fit snugly the spindle of the turret-lathe. A hole was then bored straight through from the face at *B* and threaded as shown, getting it dead true. The front was then faced, thus insuring the lubrication of the entire surface.

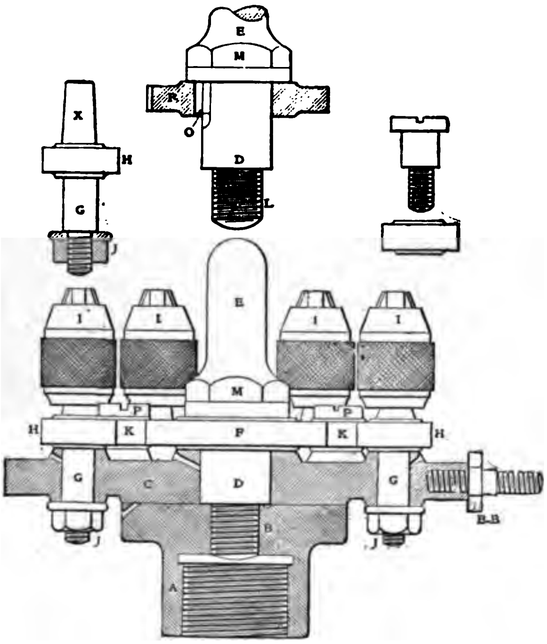

FIG. 202.

The stationary disk *C*, a circular casting with bosses on each side, to the number of thirteen on the front and seven on the back, was then machined. The central hole for the spindle *D* was first bored and reamed to size, a mandrel was driven in, and both sides were faced, leaving all the bosses the same height. We were now ready to locate and finish the holes for the six spindle-gears *H* and the intermediate gears *K*. A stud of tool steel was turned up, hardened and ground to fit the central hole in the disk tightly. We then finished up six buttons of the type used for accurate jig-making, and ground them to 7/8-inch on the outside and the ends perfectly square. The central stud was entered into the hole and one of the buttons was located the exact distance from the centre by using the verniers and deducting the diameter of the stud and button. The button was then fastened to the disk by its screw, being located as nearly in the centre of the bosses as possible. The second button was located the required distance from the first and from the centre of the stud in the same manner, and this operation was repeated until all six buttons were located.

The disk was clamped on the lathe face-plate and the central stud removed. The first button was trued and removed, and a ½-inch hole drilled, bored, and reamed entirely through the disk. The next button was then located, trued, and removed and the hole bored and finished in the same manner; repeating until the six holes were finished. We were now sure of the accuracy and position of the gears when placed, and the interchangeability of the holes when drilled. Before drilling and tapping the holes for the six intermediate gears, the gears were turned and cut.

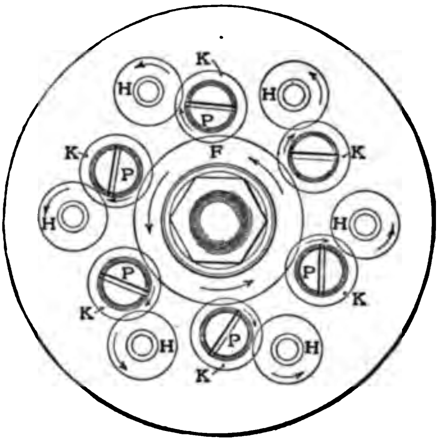

FIG. 203.

The drill-chuck spindles and gears were each in one piece and were mild-steel forgings which were first centred and faced the same length. The spindle portions *G* were turned to within .005-inch of the finish size and the ends threaded for the nut, leaving a shoulder for the washer. The taper portion for the chuck was turned, leaving the same amount of stock for finishing as on the other end. The gear portion *H* was then finished to the required diameter, and all were finished in the grinder, with the portion *G* a smooth running fit in the reamed holes in the disk, and the sides of the gears ground perfectly flat and true with the spindles. The teeth were then cut.

The six intermediate gears *K* also were of steel; and six shoulder-studs or screws were made of tool-steel for them. The large, or driving-gear *F* was of cast-iron and was bored and reamed to the same size as the central hole in the disk; the sides were ground as the others, and a keyway let in for fastening it to the spindle and leading stud *D*. The portion *D* of the stud turned within the disk after hardening. A second shoulder was left at *M* so that the space between it and the first would accommodate the disk and the driving gear. A hexagon was milled

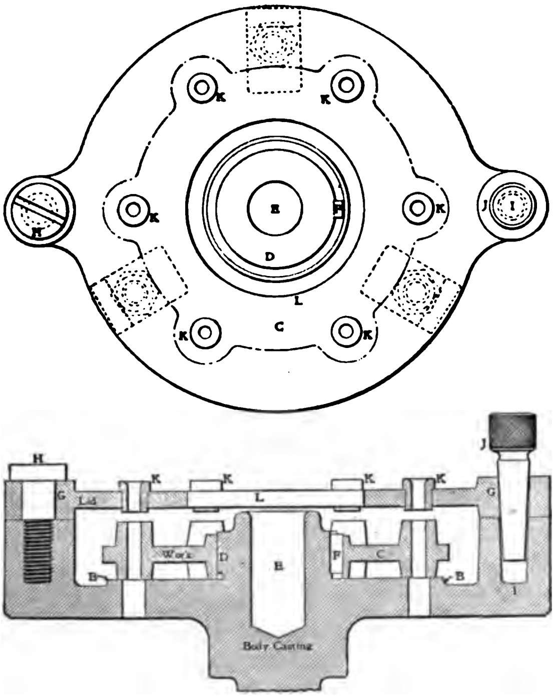

FIG. 204.

at *M* and the stud reduced for the remainder of its length, the end rounded to act as a leading stud and enter a reamed hole in the work fixture when in operation, to support it. The six holes for the intermediate-gear screws were then drilled and tapped, so that the gears would occupy the positions shown in the plan. After drilling and tapping the hole for the stud *B B* all parts were assembled, as shown, the chucks being driven tightly on to the spindles.

The fixture for locating and fastening the work is shown in Fig. 204. The body casting is machined first. After being centred it has the stem turned to fit the hole in the turret-head. It is then reversed and held by the finished stem in a nose-chuck and the front is finished, first taking a cut off the two projecting bosses *G G*, then finishing the seat for the work and turning the hub *D* to fit nicely the large central hole in the work (undercutting it at the back to prevent dirt or chips from accumulating), and, lastly, boring and reaming the centre hole *E* for the leading stud of the drilling and tapping attachment. Before locating and letting in the key *F* in the hub *D* the lid was finished and fastened to the body casting and the holes for the drill-bushings were let in.

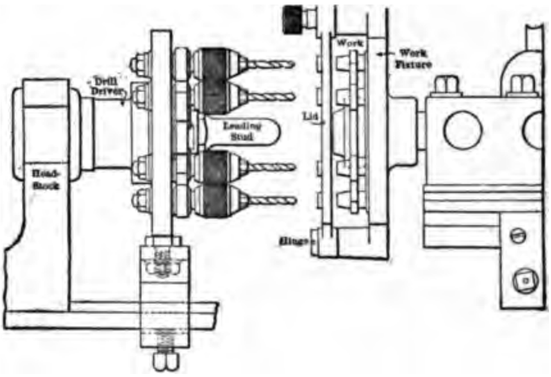

FIG. 205.

This lid-casting is circular, with a large hole *L* in the centre and raised bosses at the opposite sides where it is hinged and located to the body casting. These bosses were faced and a cut was taken off one side of the casting for the bushing-heads to locate. The lid and the body casting were then clamped together so that the boss faces rested true with each other, and the hole for the hinge-screw *H* was let in, tapping it in the body casting and enlarging and reaming it to a snug fit for the large portion of the screw in the lid. The screw *H* was then let in and the hole *I* drilled and reamed for the taper locating-stud *J*. We were now ready to locate and finish the bushing-holes. The taper locating-pin *J* was forced in tightly and a hardened and ground plug was finished to fit tightly the hole *E*. Then by using the buttons used for locating the spindle holes in the drilling and tapping attachment these six holes were located in the same manner. The hinge-screw *H* and the locating-stud *J* were then removed, the lid was clamped to the face-plate, the buttons made true, and holes bored and reamed to the required size. The bushings *K* were made of tool steel and forced into the holes in the lid. Three holes were then drilled and tapped in the body casting in the positions shown by the dotted lines in Fig. 204 to accommodate the clamp-screws. These three clamps are only used when tapping the holes, the lid being then removed. After the six clearance-holes for the drills and taps were drilled and the key let in so that the bosses of the casting would cam approximately correct, the fixture was complete.

In Fig. 205 is shown the manner of setting up the multi-spindle attachment and the work fixture. The driver, or back plate of the attachment is screwed on to the spindle of the turret-lathe. A clamp-strap of $\frac{3}{8}$-inch thick flat iron, bent to the shape required, with a hole in the centre for the stud *B B*, Fig. 213, and the ends bent inward and set-screws let in, was then secured with the ends fastened to the body of the lathe and the stud *B B* fastened to the strap by the nut, thereby locating and fastening the spindle-disk without the possibility of shifting when in operation.

The work fixture was located by entering the stem into one of the holes in the turret-head, the slide moved up, and the fixture manipulated until all six drills entered the bushings of the fixture. The fixture was then fastened, the lid was thrown back, the work or casting to be drilled located by the key on the hub of the fixture, as shown, and the lid or bushing-plate relocated by the taper plug. The lathe is started, and as the driver revolves, and with it the driving gear, the spindle-disk remains stationary, allowing the six drills to turn at the speed desired. The turret-slide is moved up, the six holes are drilled in the work, the finished piece removed and replaced by another, and the operation repeated. After all the castings in the lot have been drilled they are tapped by simply substituting taps for the six drills and removing the bushing-plate from the work fixture. The locating of the castings so that alignment of the drilled holes with the taps will be perfect is accomplished without any trouble, as the keyway in the casting brings them in the same location as in the first or drilling operation, and the three clamps hold it tightly in position. When tapping, the spindles are run at the proper speed and the work is brought up to the taps, the operator keeping his hand on the shifter, and as soon as the taps have come through the holes the lathe is reversed and the taps are fed out.

CHAPTER XIII.

Special Tools, Fixtures, and Devices for Machining Repetition Parts in the Screw-Machine.

FOUR SPECIAL BOX-TOOLS FOR THE SCREW-MACHINE.

The tools shown and described in this chapter were designed for and used in the screw-machines, but many of the designs are adaptable with slight modifications to the turret-lathe as well.

The tools shown in Figs. 206 to 209 are for making small tubes used for perforating leather shoe-tips. These tubes run from $\frac{1}{16}$- to $\frac{1}{4}$-inch in diameter, are made from drill rod, and are required to be finished with a smooth reamed hole through them true with the outside, and with one end chamfered to a sharp edge. In producing the larger sizes of tubes very little trouble was encountered, but for the smaller sizes (and they were required in the largest quantities) much trouble was met with. All trouble, however, was overcome and very good results attained by the use of the tools shown herein.

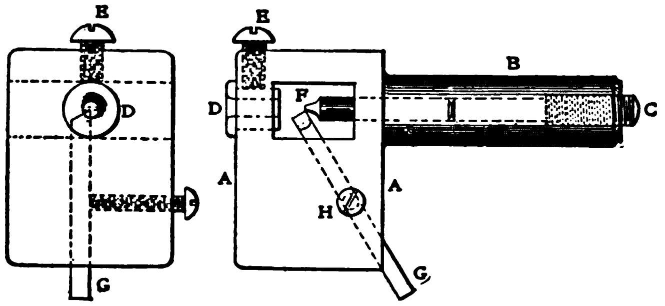

FIG. 206.

Fig. 206 is for chamfering the ends and centring the tubes. The body or box portion, of cast-iron, has a hole through it for the entering-tool *F* and its adjusting-screw *C*. A hole is broached through the body for the chamfering-tool *C*, at an angle which allows the face of *C* to be ground square. The bushing *G* is of tool steel, is hardened and lapped to the size of the drill-rod.

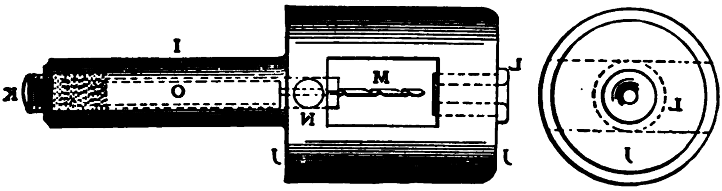

FIG. 207.

By chamfering the end of the tubes with this tool, before drilling and reaming the hole, a sharp edge can be produced.

Fig. 207 shows the tool for drilling the tubes. The drill is held in a split bushing by the adjusting-screw *K* and round-head screw *N*. The bushing *L* is forced into the holder.

Fig. 208 is for cutting off the tubes. On account of their smaller diameter it is necessary to support the stock during the operation. The body of the tool is of cast-iron. The cutting-off tool is of a somewhat special construction. It is of a ¼ × ½-inch stock finished all over to fit within the channel, and with a groove in one side for the feather *U*. The grooves *V* on the bottom are for the collar of the feed-screw *W*. The cutting end of the tool *T* is finished to the usual shape required for such a tool; as narrow as possible, according to the size of the stock. These three tools produce the perforating tubes to the degree of interchangeability and accuracy required, and in a very rapid man-

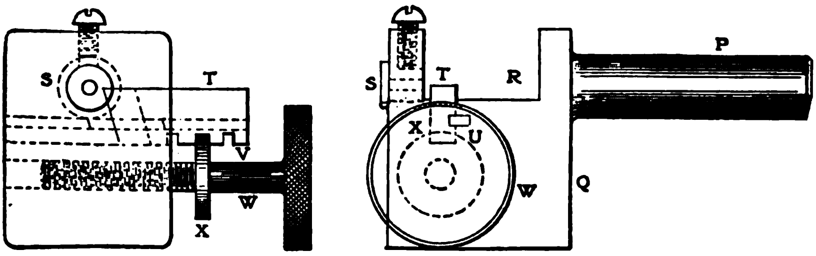

FIG. 208.

ner. The tubes, after being thus finished, are hardened and tempered to a dark blue, and are forced into radial holes in a mild-steel disk. Different combinations of sizes of tubes are located in these disks, to produce the pattern desired in their leather shoe-tips and miscellaneous leather findings.

The box-tool, Fig. 209, is of a distinctly different type from those above described; it is used for pointing slender needle valves on an incandescent oil-lamp of well-known make. It is rather difficult to point wire of small diameter by the ordinary means available in the screw-machine, especially if the points are to taper quite gradually, as at *M*. By the ordinary method the cutting surface of the tool would be so wide that it would be almost impossible to keep the wire true and hold it sufficiently rigid. The body or box portion of the tool is a forging of mild steel, with a rectangular hole at *B* and a tool-steel bushing at *C*. The cutting-tool *E* is fitted snugly into a square broached hole, the side of which is in line with the end of the bushing. The rear end of the tool is threaded for adjustment nut *G*. A bracket is fastened to the body of the tool, and the spiral spring, which is required to be quite stiff, is located as shown. A hole is let into the body at *D* as clearance for the angular-faced tool-post fixt-

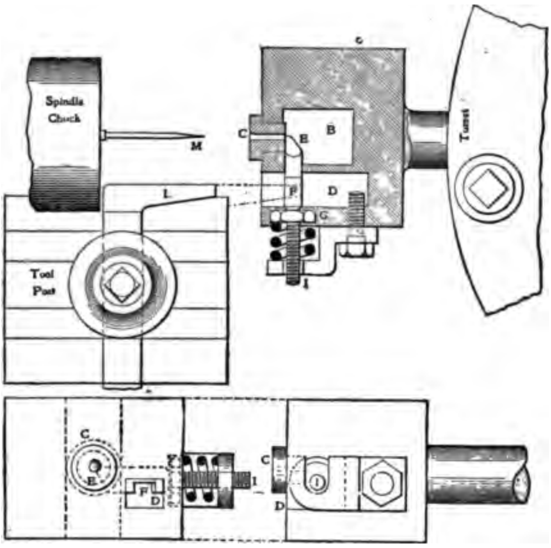

FIG. 209.

ure *L*. A channel *F* is let into the under side of the pointing-tool *E*, with a taper side at the rear coinciding with the taper of *L*. In first operation the cutting tool *E* is allowed to project, adjusting it by the nut *G* slightly beyond the centre bushing *C*. As the box-tool is brought up to the work, the wire enters the hole *D*. As the tool *E* begins to cut, the engager *L* commences to force the tool back, and continues to do so until it ceases to cut and the wire is pointed as shown. The turret is then brought back, and the spring causes the cutting-tool to resume its former position.

SCREW-MACHINE FIXTURES AND TOOLS FOR MAKING SPEED-INDICATORS.

The sketches herewith are of two special chucks and of a tapping-machine which were designed by Mr. W. J. Parker, foreman of the Fulton Machine Works, Broooklyn, the chucks being used for machining a casting (Fig. 210) which forms the body of a speed-indicator manufactured by that firm. The work on this casting was the boring out of the large circular portion *A* for the revolving dial-plates of the indicator; the facing of the bottom *B* and of the hub around which the dials revolve, and the drilling of the small hole *C* in the centre of this hub. All this was accomplished in one operation, after the work had been fastened in the chuck (Fig. 211). The second operation was the boring and reaming of a hole *D* (Fig. 210) for the spindle of the indicator and the finishing of a centre and thrust bearing for the end of it at *E*. Both chucks are used in the screw-machine in conjunction with a set of turret-tools for each.

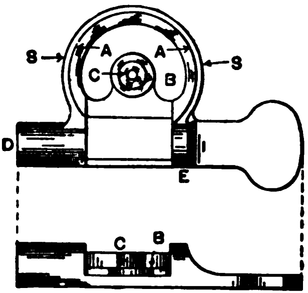

FIG. 210.

Fig. 211 shows the chuck used for the first operation. It consists of a circular casting having a hub at the back and a raised portion on its face for holding the work. The casting is fitted to the screw-machine spindle, and faced and bored to admit the large circular portion of the work as shown at *L*, being bored to a depth sufficient for the upper side of the work to project slightly above the face *H* of the chuck. The face of the chuck is milled away on each side of the square central portion *H* so that the work may be easily located or removed. *J* is a flat machine-steel plate, located on the face of the chucks by two dowel-pins *K K* and fastened by the four corner screws *L L L L*. This plate, while fastened to the main casting, is bored sufficiently to tightly clamp the edges of the large circular portion and for clearance for the cutting-tools. Fig. 211 shows clearly how the work is located and clamped on the chuck. The work is machined by the usual type of turret-tools.

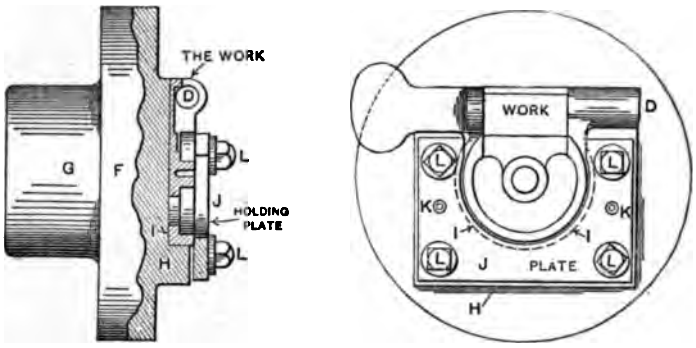

FIG. 211.

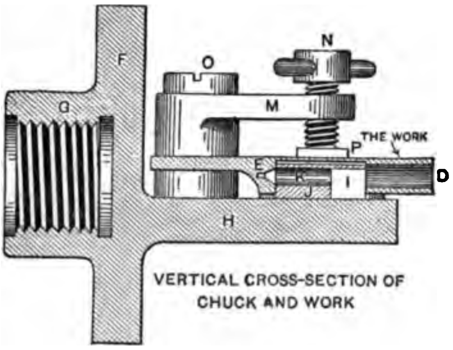

FIG. 212.

The second operation is accomplished by the use of the chuck shown in Fig 212, which is of distinctly different design from that of the chuck Fig. 211. It is a circular hub-backed casting, with a rather long, flat, projecting standard at *H*, fitted, as in the other case, to the screw-machine spindle and having the face of *H* machined flat and square with the face of *F*. The work is located on this projecting face at two points by *K* and *J;* also at *I* by a circular machine-steel disk fitting within the portion *A*, Fig. 210, of the work and fastened to the face *H*, Fig. 213, of the chuck by screws and dowel-pins (not shown) and at *K* by the steel plate *J*, which, as will be seen, is fastened by screws and dowel-pins. For clamping the work to the chuck the swinging bracket and clamping-screw *N* are used, the construction of which is shown in the cross-section view of Fig. 214, where the work is shown fastened upon the chuck. The work machined in these chucks is, needless to say, perfectly interchangeable.

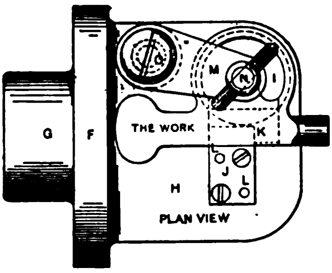

FIG. 213.

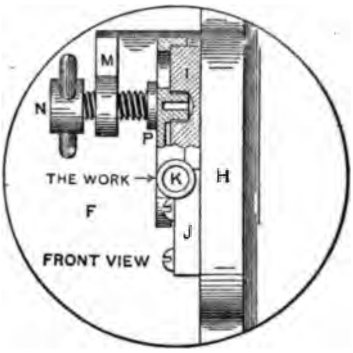

FIG. 214.

METHOD FOR FINISHING DUPLICATE WORK IN THE SCREW-MACHINE.

The special tools and fixtures here described were designed for the screw-machine, and consisted of an improved driver for the work; a special arrangement of lathe centres, and a forming-tool and holder which will duplicate work without chattering and without regard to pressure applied by the operator.

The particular piece of work for which these tools were designed is shown in two views in Figs. 215 and 216 and is called a "goose-neck." It is a brass casting, and is finished at the taper end marked *A*. Before finishing this surface, the castings were centred at *C*, and chamfered slightly on the inside at *B*. The first fixture made for the finishing operation was the special chuck, a cross-section of which is shown in Fig. 217. The body of the chuck was a casting of the shape shown, and was bored out at *C C*. It was first chucked in the lathe and bored out and threaded at *G G* to fit the spindle of the screw-machine, and then squared up. It was then faced and the rim trued. A hole was bored and threaded at *D* to admit the centre *E*, which was finished with a shoulder at *F* so as to allow it to rest squarely

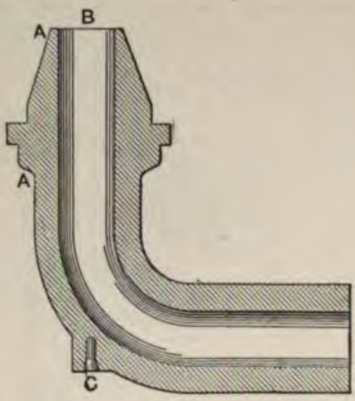

FIG. 215.

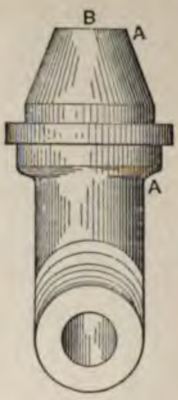

FIG. 216.

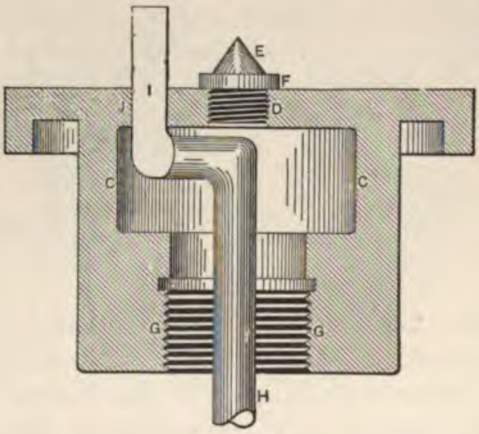

FIG. 217.

against the face of the chuck. A square hole was then let through the face of the chuck to admit the driver *I*, which was made of ⅜-inch round tool steel and bent as shown, and the end *I* finished to a smooth fit within the hole *J*. The round portion *H* of this driver was long enough to allow it to extend clear through the screw-machine spindle, and was connected to the wire-feed lever. This manner of connecting the driver allowed it to be forced out and in, thereby permitting the work to be located on the centres, and removed when finished without stopping the machine.

As the edge *B* of the work, Fig. 215, gives a very narrow bearing for the tail-centres, and as the work revolved very fast, it was not practical to adopt the ordinary centre, as there was a tendency for the end of the work to run hot and burr up. So, to overcome this, the special sleeve and running-centre, shown in a cross-sectional view in Fig. 218, were made. This fixture consists of a sleeve which was first bored out and tapped at the back end for the centre end-thrust screw *M*. It was then placed on an arbor and turned taper on the outside to fit the tail-stock, which had been fitted to the screw-machine. The end-thrust screw *M* was then made with thrust end finished flat, hardened and pol-

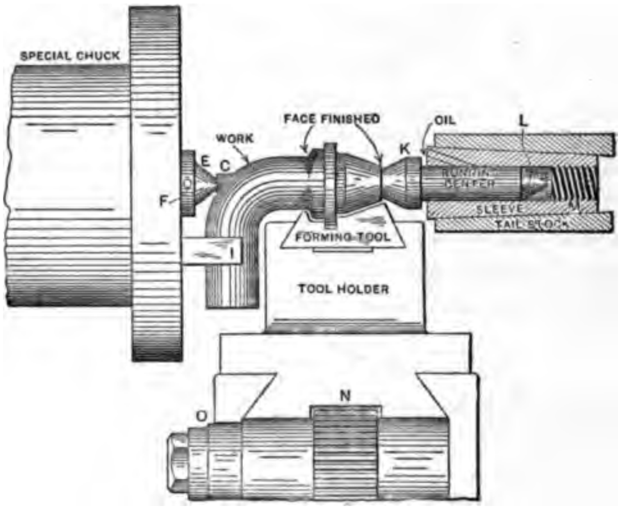

FIG. 218.

ished. It was then screwed tightly into the sleeve. The running-centre *K* was then made of tool steel and finished to fit the sleeve smoothly, and tapered at *L* and the point rounded. This end was then hardened and polished. After an oil-hole had been let into the sleeve and the inside polished smooth, the fixture was finished.

As the manner of finishing the formed surface of the work is distinctly different from the usual methods in general use, and as the forming-tool and holder are of a novel design, they are worthy of a detailed description.

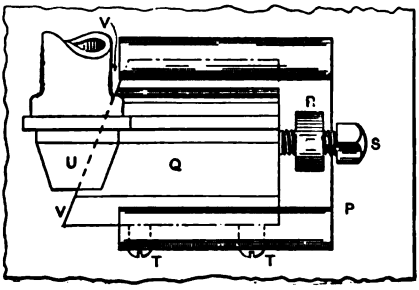

FIG. 219.

By referring to Figs. 219 and 220, in which a plan and side view respectively of the tool and holder are shown, the following description of them will be intelligently understood. The holder is a casting of the shape shown at *F*, and was dovetailed on the bottom and fitted to the cross-slide of the screw-machine and equipped with a rack to mesh with the feed-gear, as shown at *N*, Fig. 218. The portion for holding the forming-tool *Q*, Fig.

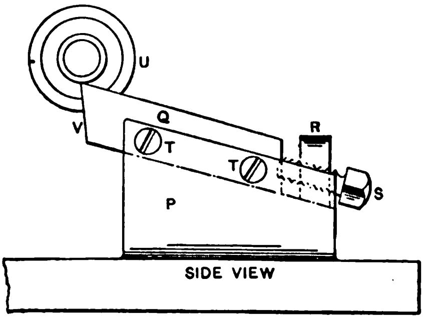

FIG. 220.

219, was then planed dovetail, slanting upward to the degree shown in the side view of Fig. 220. A hole was then drilled and tapped through the lug *R* to admit the tool adjusting-screw *S*. Two headless set-screws *T T* were also let into the side, as shown. The forming-tool *Q* was of ¾-inch flat tool steel, finished all over, and fitted to the holder as shown. The shape required was then worked out on the face for its entire length, and finished in the milling-machine with a special fly-cutter, as shown in Fig. 218. The cutting-face of the tool, *V V*, Fig. 219, was sheared off to the angle shown, so as to allow the work to be cut gradually. The tool was then hardened and drawn to a light-straw temper, and the cutting-face ground and oil-stoned to a keen edge. The fixture and tools were now complete and ready for work.

The parts were set up in the screw-machine in the relative positions shown in Fig. 218. The machine was started, and the driver-lever pulled back, thereby drawing the driver *I* into the chuck. The work was then placed on the centres, with the portion *C* on the chuck-centres and the face end on the running-centre *K*. The driver-lever was then pulled out, causing the driver *I* to emerge and drive the work, the running-centre *L* travelling with it. The handle *O* of the cross-slide was then pulled down and the forming-tool presented to the work, cutting the face gradually. And as each portion of the work was reduced and finished, that point of the tool passed the centre and came out under the work; and as the whole face was finished, the entire cutting-face of the tool passed free and clear of the work. The driver *I* was then drawn in (without stopping the machine) and the tail-centre drawn back and the work removed. Another casting was then located on the centres, the driver sent out, and the work finished as before.

As will at once be seen, the use of the special chuck reduces the time necessary to locate the work on the centres, and remove it when finished, to the minimum. And the running tail-centre eliminates the possibility of the work running hot and burring, as well as the waste of time in adjusting the centre against the work. The methods of finishing formed surfaces by means of tools of the design shown is meeting with more favor all the time, as very wide and intricate forms can be duplicated on round work without any trouble. Another thing, by the use of this tool work can be finished, one piece in exact duplication of the other.

FIXTURES FOR FORMING PIECES OF IRREGULAR OUTLINE.

In the preceding chapter a fixture for forming pieces of irregular outline from the bar was described, which fixture was adapted to work having considerable stock to be removed. The tool here to be described consists of a similar fixture for use in the screw-machine for forming irregularly shaped surfaces, but from individual castings instead of from the bar, and in which less metal is to be removed.

The article for which this device was used is an improved gas-stove cock made in two parts, each of which is of irregular exterior outline, as shown in the longitudinal sectional view in Fig. 221. The length of the assembled cock over all is 4$\frac{3}{4}$ inches, and the pieces are composition castings with the holes *K* and *F* cored in them. Certain preliminary minor operations are necessary on both parts 1 and 2 before the forming-cutter is used, in order to form the threaded hub *C C* on part 1 and the threaded recess *B B* in part 2 for a means of definitely locating them on the face-plate, which operations will be described later on.

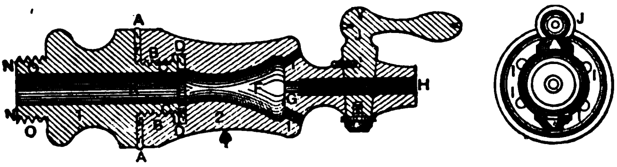

FIG. 221.

The forming-cutter used for obtaining the irregular outline surface is one of the circular forming type of cutters, which is shaped entirely around its exterior surface, the cutting-edge being produced by milling out a longitudinal groove on its exterior as shown in Figs. 222 and 223. This is the type of cutter that may be ground and reground almost indefinitely without altering the shape of its cutting-edge if the body of the cutter is properly shaped. The cutter shown in Figs. 222 and 223, which represent the cutter used for machining the surface of part 2 of the gas-cock, was made of tool steel, which was annealed and bored out at *D* and a keyway let down through the entire length at *C*, after which it was driven on to an arbor and the ends finished as shown at *B B*, and the required shape turned on to the outside from end to end to templet, as shown. The finishing of this forming was done very carefully by first roughing it out with the usual lathe-tools and then using a variety of hand-tools to finish it to shape. Especial care was taken to get its entire surface smooth and free from marks, and it was finished to a dead-

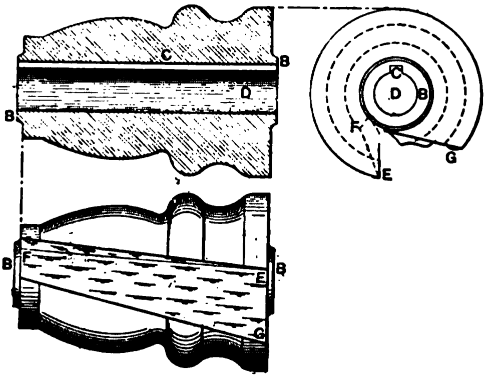

FIG. 222.

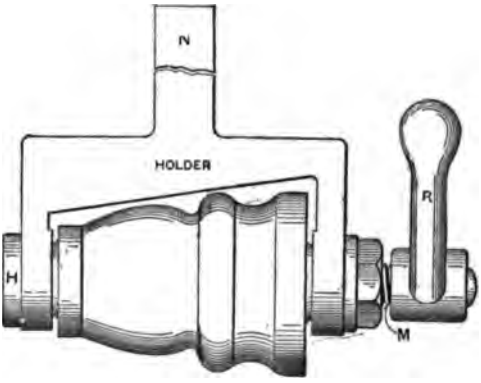

FIG. 223.

smooth finish by means of lapping with stick, emery, and oil. This was necessary, as the work was required to have a high finish after being machined, and as the manner in which the cutter was presented to the work allowed of its burnishing the same as soon as the cutting-edge had removed the required amount of stock and passed the centre.

After being lapped, the cutter was set up in the milling-machine and a groove milled out to form the cutting-edge from *E G* to *F*, as shown in Fig. 222, it being milled on a spiral, as shown in the face view, Fig. 222, so as to cause the cutter to remove the stock progressively. In fact, the cutting-edge of the cutter was finished in the same manner as a wide-face milling-cutter, except that the spiral was not quite as abrupt. After finishing the cutting-edge as shown, the cutter was carefully hardened and drawn to a very light-straw temper, thus leaving it as hard as is consistent with reliable cutting.

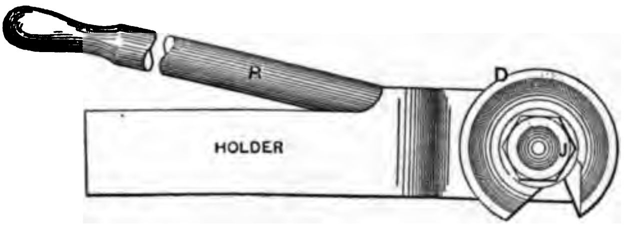

FIG. 224.

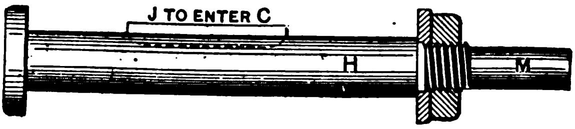

FIG. 225.

The cutting-edge was then ground on the cutter-grinder, and carefully oil-stoned so as to present a smooth, keen edge for its entire length. The holder, or bracket, shown in Fig. 223, which supports the cutter and its cutter-stud *H*, Fig. 225, was made from a forging with the shank *N* finished to fit the large tool-post of the turret-lathe. The way in which the cutter is mounted in the holder is shown in Fig. 223, which shows a top view of the cutter in place upon its stud *H* and the hand-lever *R* mounted upon the projecting end *M* of the stud.

The manner of using the fixture may be understood from Figs. 226 and 227; Fig. 226 showing a front view of both fixture and work in position, the face-plate, the turret-head, and Fig. 227 an end view toward the face-plate to indicate the manner in which the cutting-edge of the cutter is presented to the work. In machining the work the handle of the cross-slide is moved by the left

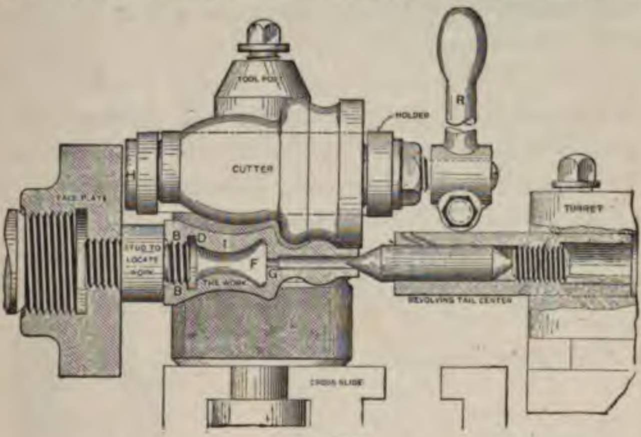

FIG. 226.

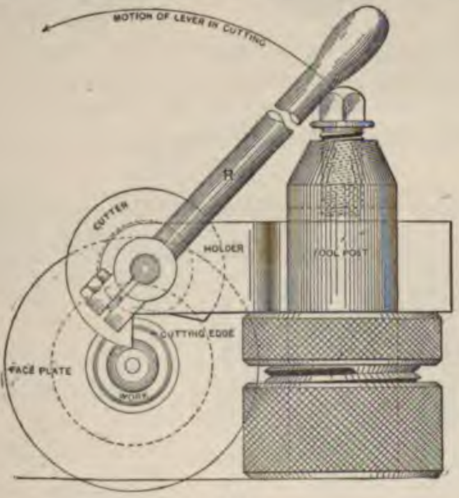

FIG. 227.

hand of the operator until the cutting-edge of the tool is in the position against the work shown in the end view, Fig. 227, and held there with the help of the feed screw of the cross-slide, while with the right the lever of the forming-tool is pulled forward. As the cutter is slowly revolved in the holder by the pressure on the lever, it cuts and removes the required amount of stock progressively, due to its spiral cutting-edge, and as the cutting-edge passes the centre line the friction of the finished portions of the work revolving rapidly against the exterior of the cutter produces a high finish of its entire surface.

The cutter which was used for milling part 1 of the gas-cock, Fig. 221, is shown in front view and section in Figs. 228 and 229, and in end view in Fig. 224. This cutter was made, tempered and ground exactly the same as was the other, and its method of use in removing the stock and obtaining the burnish or polish is identical.

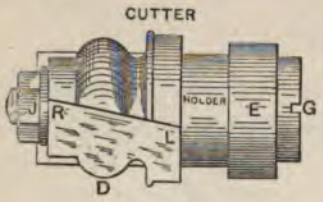

FIG. 228.

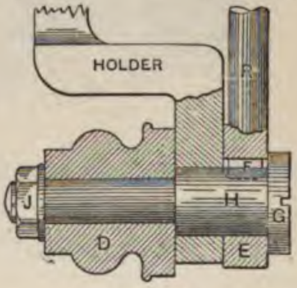

FIG. 229.

In connection with the finishing of these gas-stove cocks other fixtures were used which may be of interest. In forming the threaded hub *C C*, part 1, Fig. 221, a pair of slip-jaws for a regu-

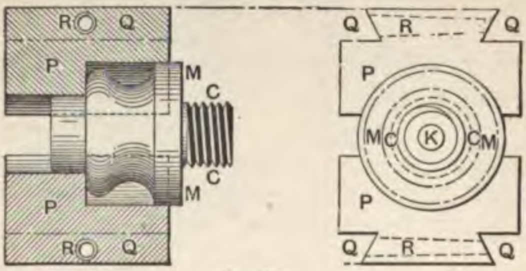

FIG. 230.

lar two-jaw chuck was used for chucking the work while machining. These jaws, which are shown in Fig. 230, are of cast-iron; are finished dovetail to drive into the jaws proper of the chuck, and are located in the proper relative positions by means of a taper-pin at *R*. The way in which these jaws are constructed and finished to allow of locating the work as shown is evident from the sketch. The facing of the surface *M M* is accomplished by means of a hollow mill, which differs from the type generally used in that it has fifteen teeth. The hub *C C* is finished by the mill also, the thread being cut by means of a collapsible die.

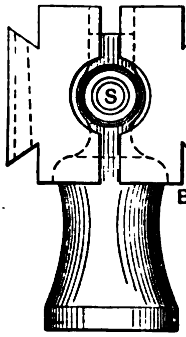

FIG. 231.

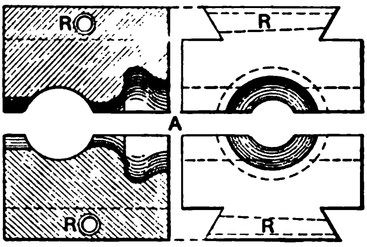

FIG. 232.

In Figs. 231 and 232 are shown the slip-jaws which are used for the first and third operations on part 2, Fig. 221, which contains the gas-cock proper. These two sets of jaws are constructed similar to the first set, Fig. 230, and are used in the same way. The part shown at *A*, Fig. 232, is for holding the casting for part 2 while the surface at *A A* is being faced, the

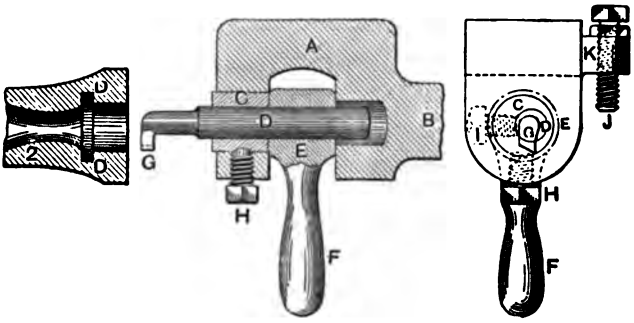

FIG. 233.

seat for the rubber washer let in at *D D*, and the hole at *B* bored and tapped to fit the threaded hub, part 1. The other set of jaws is used for holding part 2 after being machined all over, when the taper hole for the key *J* is being let in at *S*, Fig. 231, which shows the work located within the jaws and the hole drilled at *S*. This hole, after being centred in the usual manner, is reamed to the required taper by means of a "floating" reamer of the usual type.

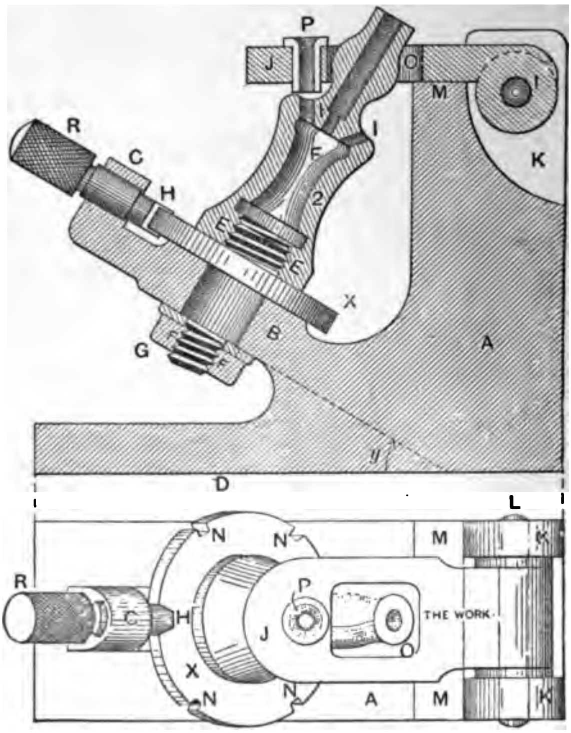

FIG. 234.

For turning the washer-seat at *D D*, in part 2, the special eccentric box-tool shown in Fig. 233 was used, which is of an interesting construction. *A* is a holder or frame, made of cast-iron, which a shank portion at *B* turned to fit the hole in the turret. *C* is an eccentric bushing located within the holder by the setscrew *H*; *G* the cutting-tool; *F* the lever by which it is manipulated. The depth of cut is regulated by adjusting the lever stop-screw *J*, which is let into the projecting lug *K* as shown in the end view of the tool. In using this fixture, after the tool *G* has been entered into the cored hole in the work the required distance, the lever *F* is raised slowly until it rests against the stop-screw *J*, which determines the proper depth of cut, then it is dropped and the tool backed out.

A novel drill-jig was designed for use in boring the six inclined air-draught holes leading into the combining-chamber *F* in part 2 of the gas-cock. The jig is shown in plan and in sectional elevation in Fig. 234, with the work in place. As is shown, these six holes are required to be drilled at an angle with the axis of the casting, and also to be equidistant, and an interesting design is the result. *A* is the body casting of the jig, which is machined on the base at *D*, and also on both sides of the projection *B*, to an angle *Y* with the base, as shown. The indexing-device *X* and the locating-stud for the work are of tool steel, hardened and ground. There are six equally spaced notches in the index-plate which coincide in shape with the end *H* of the index-pin *R* and locate the work for the six different holes. The drill-bushing *P* is located as shown in the swing-lid *J*, which is hinged within the two sides *K K* of the body casting *A* by means of the pipe *L*. A hole *O* in the lid allows clearance for the work when located in the jig; all that is necessary for removal being to swing the bushing-lid *J* back and unscrew the work off the locating-stud.

CHAPTER XIV.

The Construction and Use of Boring Fixtures and Similar Tools.

THE DRILL-PRESS AND BORING FIXTURES.

One of the things that make the large drill-press a valuable machine tool is its adaptability for performing accurate operations in the production of interchangeable parts by the use of simple and often inexpensive fixtures. In fact, I do not hesitate to state that it runs the turret-lathe a close second for the place of the most rapid and economical producer in the shop.

Now aside from the adaptability of the drill-press for jig-drilling, there is any quantity and variety of work requiring to be bored which can be handled to good advantage on this machine; and in this chapter, among other things, I will devote considerable space to describing and illustrating types for boring-fixtures which were designed to be used on the drill-press and have worked well in practice, and their presentation will

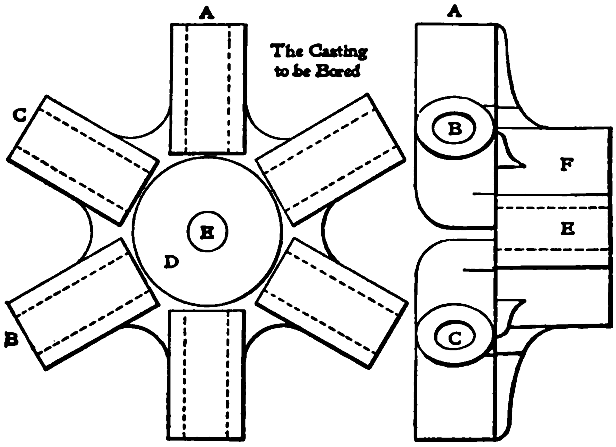

FIG. 235.

prove suggestive for others. The practical points for the designing and construction of the fixtures will assist the tool-maker in the attainment of the desired results with ease, and dispense with much unnecessary labor and expense.

BORING AND FACING FIXTURE FOR "SEXTIT" CASTINGS.

The casting shown in sketch Fig. 235 has six radiating cylinders, each with a cored hole through it. It was necessary to bore and finish the holes in line with the central hole *E*, and the opposite holes in line with each other. The jig shown in Figs. 236, 237, and 238 was made for the job.

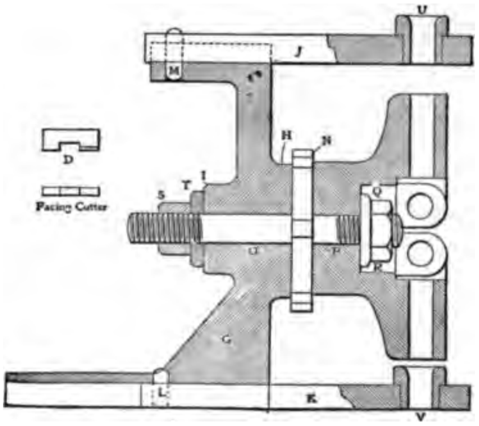

FIG. 236.

The centre hole was first bored and counterbored, and the front faced at *D*. It was then driven on to an arbor and the back faced at *F*.

The jig consists of an angle casting with a boss, faced on the back at *H* and *I* respectively, also a back extension on the top. After being planed on the bottom and dovetailed for the bushing-plate *K*, bosses *H* and *L* were faced and the top was planed and dovetailed for the upper bushing-plate *J*. It was also dovetailed on the side for the index-pin bracket *W*, and the hole bored for the clamping-stud *O*.

The two bushing-plates *K* and *J*, of machine steel, were fitted tightly into the dovetailed channels, located in line with each other, and fastened. The centres of the holes for the bushings *U* and *V* were located by setting the casting on its side on a surface-plate and striking a line from the centre of the hole for the stud *O* to the plate *J* and *K* with the help of a Brown & Sharpe height-gauge. The centre in the opposite direction, the distance from the face of the boss *H* to the centre of the bushings *U* and *V* was also marked. The plates *J* and *K* were then driven out and the holes were bored and the two bushings *U* and *V* were made and forced in. The plates were then returned to their respective positions.

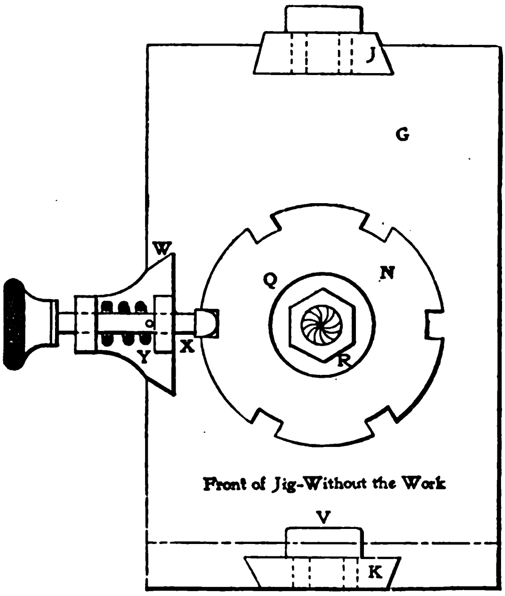

FIG. 237.

The index-plate *N* and clamping-stud *O* are in one piece. It was a mild-steel forging. The plate had on its periphery six equidistant square notches. The index-pin bracket *W*, a casting, was then fitted to drive tightly into the dovetailed channel in the side of the angle-plate. The hole for pin X was then bored.

The pin was made of tool steel, the end fitting the square notches in the index-plate, and slightly rounded to enter the notches easily. A stiff helical spring *V* was made and also a hole was drilled in the pin X for the spring cross-pin. After the handle *Z* was made all the parts were assembled.

All that remained to complete the rig was the boring-bar, Fig. 239, and the two sets of cutters *B B* and *D*. This bar was of machine steel, turned taper at the end to fit the drill-press spindle, and for the rest of the length a running fit in the bushings *U* and *V*. The bar was small enough to clear the cored holes. Two sets of cutters were made, one set for roughing and the other for finishing. These cutters were fastened in the bar by taper-keys. The jig was strapped to the table of a large drill-press. The index-plate *N*, with the pin X in one of the notches, was clamped and a casting to be bored clamped in position on it, so that the boring-bar would be as nearly central as possible in the cylinder to be bored. The roughing-cutters were then fastened in the bar and the holes were bored. These cutters were then removed and the finishing pair were substituted and the holes were finished.

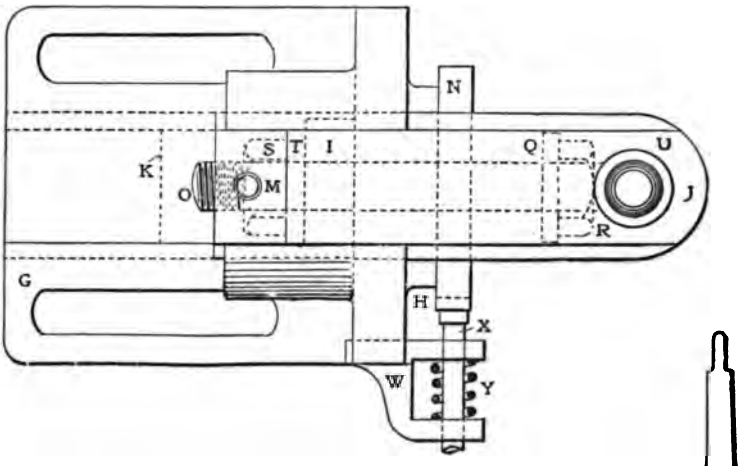

FIG. 238.

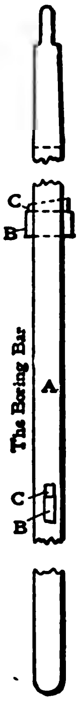

FIG. 239.

After all six holes were bored, which required only three adjustments of the index-plate, both ends of all six cylinders were faced by using the cutters *D*. All the castings, of which there were a large number, were bored and faced in this manner, and were found, when assembled with other parts, to interchange perfectly.

DRILL-PRESS BORING RIG FOR INTERCHANGEABLE WORK.

The tools described in the following were used for boring and finishing the cast-iron shell shown at *B*, Figs. 242–243. The part finished is shown at *F*, being a seat for a brass ring that was to fit in snugly so as to be air-tight, and it was also necessary to have them all exactly the same size. The shells were being made in lots of five hundred.

The jig for holding the shells is also shown in the two views. *A* is the jig, of cast-iron, which was faced off on the bottom and strapped true on the face-plate of the lathe by the ears *E E*. It was then bored out to the shape and size of the shells at *C* and a hole bored in the bottom for the plug *D*. It was then milled out at three places on the top to give the three wings *D* clearance. The plug *D*, made of machine steel, was then turned and finished so as to just fit the inside of the shells, as shown, and then driven into the jig *A*, projecting through at the bottom, as shown. The part projecting through just fitted the centre hole in the table of the large drill-press in which the boring was done.

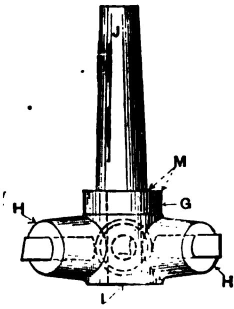

FIG. 240.

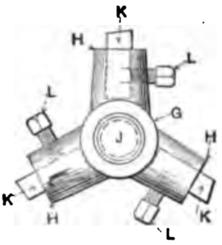

FIG. 241.

Figs. 240 and 241 show the holder and tools for boring, which were made in the following manner: *G* is the holder proper, made of cast-iron with three wings, to allow of using three cutting-tools, as we found after experiment that this number worked the best. The tool was first chucked and the hole *I* bored and reamed for the shank *J*. It was then removed and the shank *J* turned and finished to fit the spindle of the drill-press, with a shoulder at *M*. The other end was turned down so as to drive snugly into the holder *G*. The assembled tool was then put between centres in the milling-machine and the holes for the tools *K K K* were laid out and drilled and reamed. It was then taken out and the holes for the set-screws *L L L* were drilled and tapped. Next, the three cutting-tools were made and finished as shown. These were hardened and drawn, and inserted in their places, which completed the boring-tool.

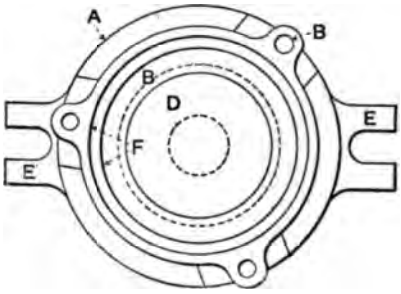

FIG. 242.

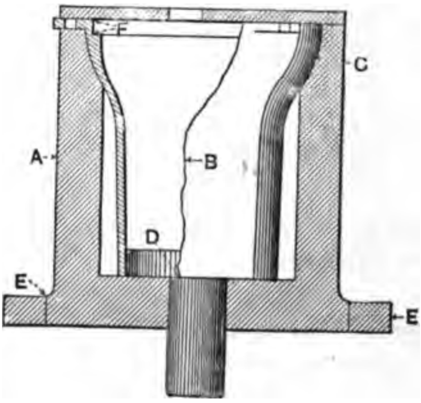

FIG. 243.

A piece of steel the size of the hole in the table was chucked in the drill-press and inserted in the hole in the table, which was locked, thereby setting it true with the spindle. The jig *A* was strapped on the table by the ears *E E*, with the lug *D* in the centre hole, and the work put in, resting on the bottom as shown in the sketch. The plug *D* centred it and the three pins not shown entered the holes in the ears *B*, which prevented it from truing. The holder, Fig. 240 was then set into the spindle and the tools set to cut exactly the right diameter, and after being run down to the proper depth the spindle-stop was set.

The rest was plain sailing and, except for stopping to sharpen tools at long intervals, the pieces were turned out very rapidly (each and every one alike) at a very small cost and much better and cheaper than they could have been done by any other practical means. The saving in the first one hundred shells paid for the cost of the tools.

A SPECIAL MACHINE FOR BORING BRACKETS AND SPINDLE-HEADS.

When constructing sensitive drill-presses of from one to five spindles, the boring of the hole for the spindle in the upper bracket and the spindle-head is done after all the other work has been done and the upper column, upper bracket, and spindle-head assembled. In the following, Figs. 244 to 247, I show and describe a machine which was designed specially for doing this work—that is, for boring the spindle holes in drills of from one to five spindles.

As this tool or machine is designed to be used and fastened directly to the columns while the holes are being bored, the possibility of error in the alignment of the spindle when assembled is reduced to a minimum; also, the manner of locating and fastening the tool to the work while in operation is as reliable and positive as could very well be devised for the class of work for which it is used. The tool consists of, first, a body casting *K* of the shape and design shown in Figs. 244, 245, and 246. The driving-spindle *Y*, with a tight and a loose pulley, *W* and *W W* respectively, at one end, and a bevel-gear *V* at the other. In the head *Q* is the spindle-driving gear with the two driving-pins *R R*; *O* is the spindle or cutter-bar, and *S* the bar-driver, while *H* is the means for feeding the pinion, which engages the rack, on the bar or spindle. The sets *M M M M* in the lugs which project above the face of the plate or body casting shown, are for bracing and holding securely the brackets and heads while they are being bored. *P P*, in the spindle *O*, are the cutters, while the adjustable angle pieces *J J*, and the clamping-levers *L L*, are for fastening the rig true and positively to the columns while in operation.

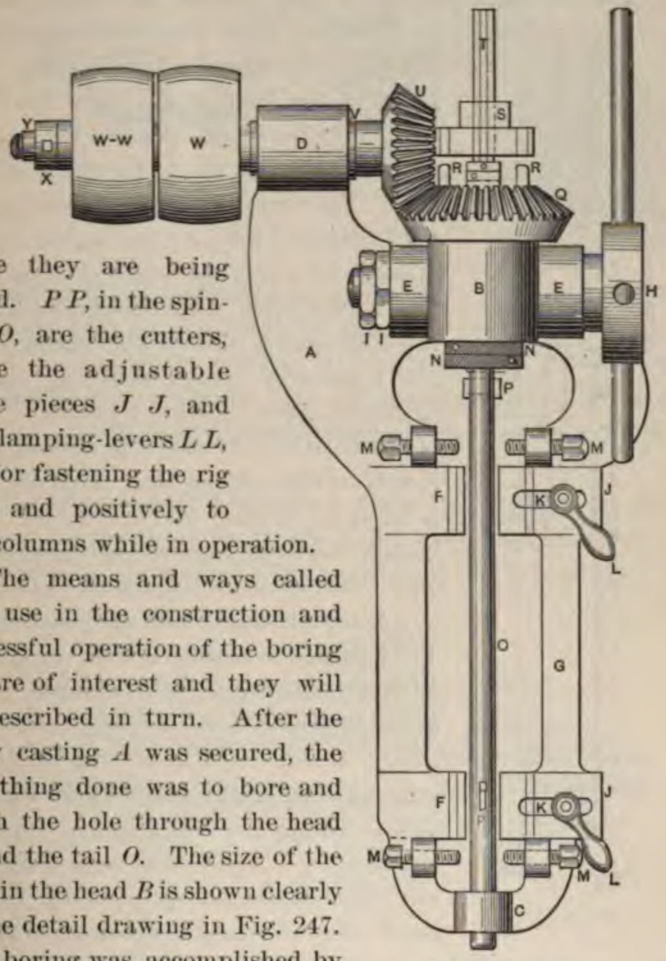

Fig. 244.

The means and ways called into use in the construction and successful operation of the boring rig are of interest and they will be described in turn. After the body casting *A* was secured, the first thing done was to bore and finish the hole through the head *B* and the tail *O*. The size of the hole in the head *B* is shown clearly in the detail drawing in Fig. 247. The boring was accomplished by strapping the casting lengthwise on an angle-plate, which, in turn, was fastened to the table of the large drill-press—first drilling a clearance-hole through both head and tail large enough to allow of the boring-bar (used for finishing), being entered through both the head *B* and the tail *C*, getting them approximately central in each. A bushing which just fitted the hole in the centre of the drill-press table, and within which the bar would fit snugly, was then tapped in and located in the table. This was for strengthening and centring the boring-bar. The bar and cutters were then centred, the table clamped in position, when the holes were bored and finished to size required in each. The front of the head *B* was then faced, by using a cutter of sufficient width.

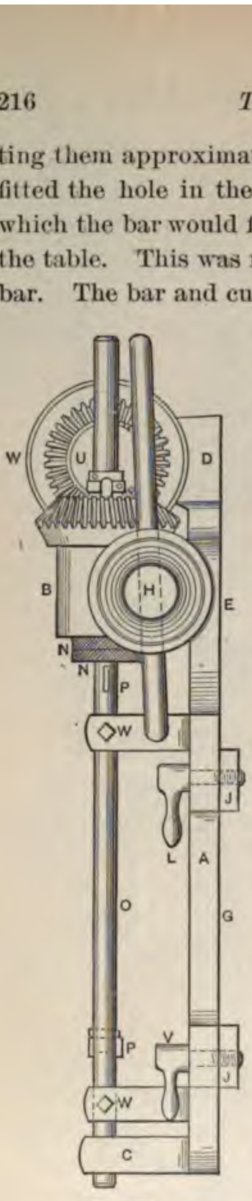

FIG. 245.

We were now ready to plane off the base. This was done by first securing two "*V*" blocks, with a tongue on the bottom of each, by which they were set dead central to each other (by entering the tongue into the central slot in the planer bed), and a piece of turned steel long enough to extend about six inches outside of each of the holes bored, and to fit each of them snugly. The casting was then set, and secured by resting the bar on the "*V*" blocks, and clamping and casting at either end. This made the alignment of the hole at a true right angle with the planer-head. The base of the casting *A* was then planed perfectly flat for its entire length, as far as the lugs or extensions *F F*, which were planed to the angle shown at *G*, or the same as that of the columns on which it was to be used. The distance from the centre of the hole in the head *B* and the tail *C* to the extreme point of the planed angle at *G* was exactly one-half of the width of the dovetailed slide of the columns. This done, the casting is removed from the planer and reset on the drill-press by strapping to an angle-plate, and the hole bored in *D* for the driving-shaft *Y*, care being taken to get it at right angles and central with the hole in the head and tail, and the necessary distance from it, to allow of the two bevel-gears *U* and *Q* meshing correctly. This hole is bored sufficiently large to allow of a machine-steel bushing *V* being driven in to act as a bearing. The hole for the rack-pinion in the bosses *E E* is also bored and finished, to the size required at each end, in this setting, boring the large part deep enough to allow of the pinion being inserted therein. The casting is then removed and the holes drilled and tapped for the four set-screws *M*, and also the slots for the adjusting- and clamping-levers *L L* let in at *K K*, as shown.

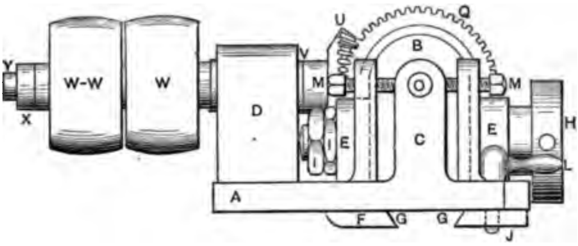

FIG. 246.

The driving-shaft *Y* was then made and finished, as shown; as were the two pulleys *W* and *W W*. The gear *U* is keyed on and the collar X keeps the loose pulley *W W* in position. This being done, we were ready to finish the construction of the head, and spindle or boring-bar. This is clearly shown in the cross-

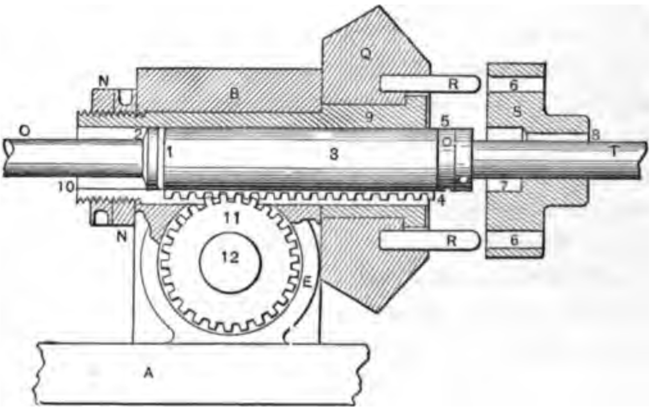

FIG. 247.

sectional drawing in Fig. 247. The first thing done was to finish the spindle or boring-bar *O*. This was turned, as will be seen, with a collar at (2) to rest against, and also threaded for the two jam-nuts (5). The rack (4) is fastened to the centre of the sleeve by letting it into a channel $\frac{1}{4}$-inch deep in the sleeve. The large shoulder-bushing is then made, and is first bored and finished to the same diameter as sleeve (3), after which it is placed on a mandrel and turned to the shape on the outside, as shown, there being two shoulders, one to rest against the face of the head *B* and the other to rest within the counterbored portion of the gear, the smallest diameter fitting the hole in the head *B* tightly, the projecting end of the portion being threaded for the two jam-nuts *N N*. The turning of the shoulders, as shown, allows of easily locating the gear *Q*, which revolves free around the outside of the bushing.

It is now necessary to plane the channel (10) through the entire length of the bushing, as a clearance way for the rack (4). This is done as shown, breaking completely through the bushing for the length of its smaller diameter, and to the same depth in its larger diameter, the stock left here being sufficient to hold and keep the bushing from expanding or warping from its original shape. Two holes are drilled in the face of the gear *Q* to admit the driving-pins *R R*, which are made, as shown, rounded on the ends, and driven tightly into the gear. The driver *S* is then made of cast-iron and bored to fit the boring-bar or spindle *O*, as shown, being counterbored on the face to a depth and diameter sufficient to clear the jam-nuts *J* and the sleeve 3. A key is then let into *S* at (8), which fits freely the keyway *T* in the spindle. The two holes (6) (6) coincide with the pins *R R* in the gear *Q*. The pinion (11) and shaft or stud (12) are finished in one piece, the stud fitting the smaller hole in *E* and the pinion resting against the counterbored back of the large one. The stud is threaded at one end for the adjusting-nuts shown at *I I* in the other three views.

All parts of the head being complete, they are assembled as shown in Fig. 247, which allows of the spindle being inserted and withdrawn freely. After the clamping-levers *L L*, Figs. 244, 245, and 246, and the angular clamps *J J* are finished and fastened, all the parts are assembled as shown in the plan view, Fig. 244, and the slots for the cutters *P P* let into the bar or spindle *O* in the position shown, at right angles to each other. The rig is now ready for work.

The column, with the bracket and heads in position, is laid flat on its back on the bench, and the boring rig (with the spindle slipped out) placed on the first column, and fastened at *G*, Fig. 244, by means of the two clamps *J*, to the dovetailed surface of it. The head of the bracket and the spindle-head to be bored project up through the openings in the centre of the body casting or base *A*. The boring-bar or spindle *O* is then entered through the head of the rig, and through the cored holes in the bracket and head, and allowed to project slightly through the tail *C*. The set-screws *M* at each side of the bracket-head and spindle-head are then screwed up, and adjusted to hold the heads perfectly rigid while they are being bored. The cutters *P P* are then entered and fastened within the bar, as shown, and the driving belt shifted from the loose to the tight pulley. The driver *S* is then slid up, until the two pins *R R* in the gear *Q* have entered the hole in it. The spindle or boring-bar is then revolving at the proper rate of speed, and is fed in by grasping the handle through the part *H*, the pinion of which engages the rack, on the sleeve of the spindle. The spindle is fed in until the holes are bored, when it is fed back, and the driver *S* pulled out and the cutters removed, and another set for finishing inserted instead, when the operation is repeated. When the bracket and spindle-head of the first column are finished, the rig is removed and clamped to the next one, when the operation of boring and finishing is repeated, and so on, until all four heads and brackets have been bored and finished to size.

As can be seen, the design and construction of this boring rig allows of its use in the boring and finishing of the heads and brackets of all sensitive drills of from one to six or more spindles; when the same design and construction is maintained in each. It also allows of being operated by comparatively unskilled help, without the possibility of spoiling the parts machined by it. Its construction is simple enough to satisfy the most exacting; while the fact that it is located while in operation directly on the columns, adds to the positiveness and accuracy of the work produced; as it does also allow of the interchanging of the parts machined.

BORING DRILL-PRESS TABLES.

On the one-spindle drills, instead of the sliding table used on the others, a flat swinging table and a small round one are substituted. The flat table shown at *A*, Fig. 248, after being planed on all sides is required to be bored at *F* to fit the turned part on the top of the column on which it swings. For finishing this hole—which was cored—a fixture for use in the drill-press was designed, and also a cutter-holder. The fixture, as shown in Fig. 249, consists of a flat casting with two raised surfaces at *B B* on which the table rests, and the four lugs, *C C* and *D D* for the locating-points. This casting, after being machined on the back, is finished on the face by first planing the raised surfaces *B B*, and then taking a cut down the front of the lugs *C C* and *D D* so as to get them at right angles to each other. The centre for the hole for the bushing *E* is then laid out and located so as to be central with the table sidewise and the proper distance from the end of the other. The hole is then bored and reamed to size required. The bushing *E* is then made and hardened, and lapped and ground to size required; then forced tightly into the hole as shown. Holes are then drilled and counterbored at the back for the clamping-bolts, *G G*. The two straps are of machine steel and are bent at right angles at one end, as shown. The straps are finished to a height sufficient to allow of their clamping the table securely.

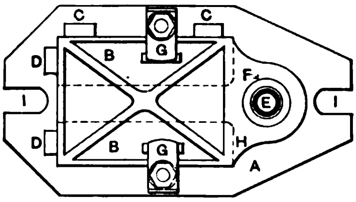

FIG. 248.

The cutters and holder are shown in Fig. 249, and as will be seen it is a plain holder with two rows of cutters set within it.

The holder *K* is of cast-iron which is first centred and turned taper at one end to fit the drill-press spindle, as shown, and at the other end, *J*, to fit the bushing *E* in the fixture. The largest portion, *K*, is turned to a diameter sufficiently small to allow the cutters to project out $\frac{5}{16}$ of an inch. The holes for the cutters were drilled by setting the holder on centres in the universal milling-machine and indexing for five, then the first row of holes *L* drilled. The second row was then drilled in the same manner, $\frac{1}{4}$ of an inch higher up at *M* and so that each hole would come between two of the first row. The cutters were made of Stub steel $\frac{3}{8}$-inch in diameter, and were finished at one end for the cutting-edge, as shown. They were then set so that the first row *L* would rough out the hole, and the second row of five cutters *M* finish it. They were held tightly in position by means of set-screws, as shown.

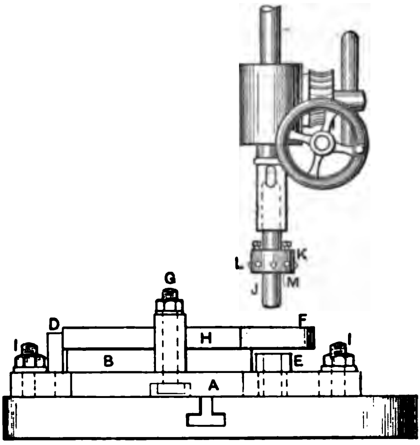

FIG. 249.

When in use the fixture was strapped on the table of the large drill-press, in the position shown in Fig. 249, by means of a bolt through each end, at *I I*. The cutter-holder was then adjusted so that the stem *J* of holder would be in line with and enter freely the bushing *E*. The table to be bored was then strapped in position on the fixture *A*, locating it squarely against the lugs *C C* and *D D*, as shown. The stem *J* of the cutter-holder was then entered into the bushing *E* and the feed thrown in and the

CHAPTER XV.

Design, Manufacture, and Use of Milling-Cutters.

MILLING-CUTTERS CLASSIFIED.

IT goes without saying that the king of all modern cutting-tools is the milling-cutter; for that reason it cannot be too fine a piece of workmanship. Of what use would be the plain or universal milling-machine without it? In fact, when considering milling-cutters it is well to remember that the milling-machine was created for it and that all the genius and excellent workmanship put into these wonderful machines are for no other purpose than to rigidly hold and revolve the cutter or cutters at the proper speed, and to feed the work to it at a rate suited to the material being milled and the type of cutter doing the work.

Milling-cutters may be classified in four distinct types. The first and probably the most common form is known as the axial, Fig. 252, in which the surface cut is parallel to the axis of the cutter. This cutter has teeth on its periphery only; these may be straight or spiral teeth. Cutters of this character, made in appropriate widths, are used very much for milling broad, flat surfaces and for cutting keyways in shafts. For deep cuts, or for slitting metal, they are made of large diameter and thin. These are called metal-slitting saws, and are ground hollow on the sides for clearance.

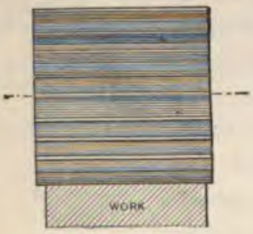

FIG. 252.

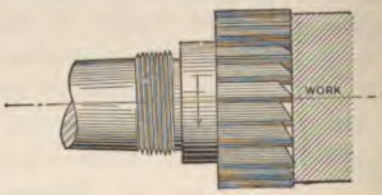

FIG. 253.

The second class of cutters is known as the radial, Fig. 253, in which the surface cut is perpendicular to the axis of the cutter. These cutters are called radial because their teeth are used in a plane parallel to the radius of the cutter. End-mills, face-mills, butt-cutters, etc., are all tools in this class.

The third class of cutters is the angular, Figs. 254 and 255, in which the surface cut is neither parallel nor perpendicular to the axis of the cutter, but is at some angle with this axis. Frequently cutters are made with two different angular cutting edges, in which case the angle is marked on each side, as in Fig. 255.

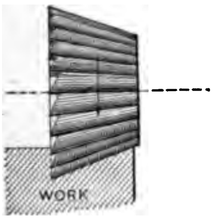

FIG. 254.

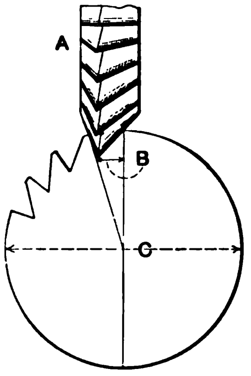

FIG. 255.

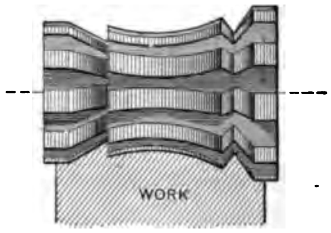

FIG. 256.

The fourth class of cutters is the formed cutter, as shown in Fig. 256. The cutting-edge of this class is of an irregular outline. When properly backed off, these cutters can be ground and retain their original form. Gear-cutters, tools for grooving taps, etc., are all classed as form cutters.

Among the numerous engravings in this chapter will be found illustrations of a large number of cutters which are used in milling-machines. In most cases it is advisable to use a cutter of small diameter rather than of large diameter. Cutters from 1½ to 2 inches in diameter are the most economical for general milling.

THE DESIGN AND MANUFACTURE OF MILLING-CUTTERS.

It is conceded to-day that one of the chief factors in bringing the process of milling into universal use and to the front

CHAPTER XV.

Design, Manufacture, and Use of Milling-Cutters.

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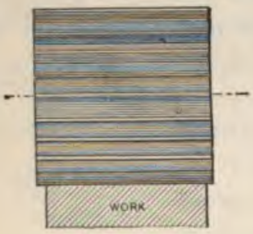

FIG. 252.

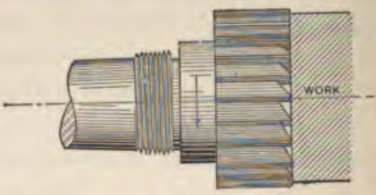

FIG. 253.

The second class of cutters is known as the radial, Fig. 253, in which the surface cut is perpendicular to the axis of the cutter. These cutters are called radial because their teeth are used in a plane parallel to the radius of the cutter. End-mills, face-mills, butt-cutters, etc., are all tools in this class.

The third class of cutters is the angular, Figs. 254 and 255, in which the surface cut is neither parallel nor perpendicular to the axis of the cutter, but is at some angle with this axis. Frequently cutters are made with two different angular cutting edges, in which case the angle is marked on each side, as in Fig. 255.

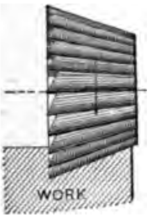

FIG. 254.

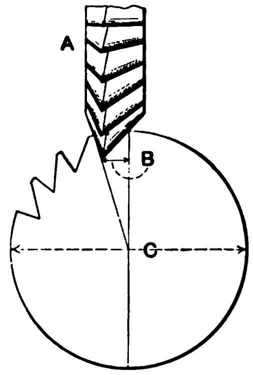

FIG. 255.

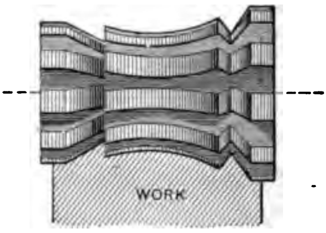

FIG. 256.

The fourth class of cutters is the formed cutter, as shown in Fig. 256. The cutting-edge of this class is of an irregular outline. When properly backed off, these cutters can be ground and retain their original form. Gear-cutters, tools for grooving taps, etc., are all classed as form cutters.

Among the numerous engravings in this chapter will be found illustrations of a large number of cutters which are used in milling-machines. In most cases it is advisable to use a cutter of small diameter rather than of large diameter. Cutters from 1½ to 2 inches in diameter are the most economical for general milling.

THE DESIGN AND MANUFACTURE OF MILLING-CUTTERS.

It is conceded to-day that one of the chief factors in bringing the process of milling into universal use and to the front rank of machine operations, was the introduction of the emery wheel for grinding milling-cutters.

So much attention has now been given to the milling process, that in many cases a degree of perfection has been attained which apparently leaves little room for improvement. It is still true, however, that even in up-to-date shops the output is below what it might be. Some firms undoubtedly have developed milling far beyond the rest of the country, but as a whole there is no reason why milling should not continue to advance during the present decade as much as it did in the past one. It should advance not only in becoming more general and more widely applied but also in the direction of giving better results.

STANDARD STYLES AND SIZES OF CUTTER.

It is now quite a common practice to use cutters which are not adapted to their work. The number of standard styles and sizes of cutters is already enormous, and neither the manufacturer nor the user can contemplate with equanimity the idea of a large increase, and yet the existing standards are inadequate for the great variety of work they have to perform. The ordinary standard cutter is intended to be used on cast- or wrought-iron, steel, or brass, and the recognized form has been evolved as the best compromise for varied work.

There are many special operations where the cutter passes through different metals at the same time, or through mica, or raw-hide or paper, or where any curious conditions arise; and the best form of cutter can only be arrived at by experiment on that particular operation. For an individual job it matters little that a cutter is not the very best design, but with repetition work it is serious to use a tool which is not capable of giving the best results.

UNDERCUT TEETH.

A turning or planing tool for iron or steel has top rake, as well as clearance below, and milling-cutters for many operations should have similar rake. From experiments, and from general experience, it has been demonstrated that undercut teeth may often be used with advantage under the following conditions: The machine should be powerful, and the cutter-arbor of ample size. The pitch of the teeth should be so coarse that only two or three may cut at the same time. The speed of cutting should be slow, and the feed sufficiently quick to allow each tooth to take a real cut. When these conditions cannot be fulfilled, there will probably be no advantage in departing from the usual form of tooth.

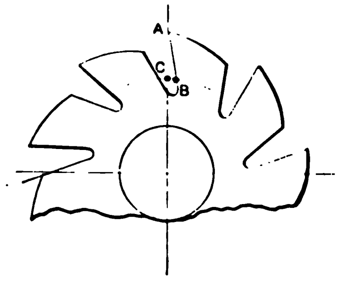

FIG. 257.

Slotting- or grooving-cutters, spiral cutters, and side-mills are well adapted for undercut teeth. Formed cutters may be so made, but there is a difficulty with the form. Thus, in Fig. 257 if the true form required is made along the cutting face *A B*, the cutter will leave a false form to the line *A C*. The difference is in most cases very slight, and always may be allowed for in making the cutter, but variations in grinding the face will alter the form. It is easy in grinding them to see when the faces are radial, but it is not so simple to give a known amount of rake.

END-MILLS.

The question of undercut teeth also arises in the case of end-mills. Three methods of cutting the teeth are shown in Figs. 258, 259, and 260. Fig. 258 shows an ordinary spiral end mill with right-hand teeth and left-hand spiral, by which arrangement the pressure from the work always tends to push the cutter into its socket. This is the correct form if the cutter is to be used for milling on the sides, if, strictly speaking, it is not to be used as an end-mill, for which it is unsuitable, because the teeth on the end have negative clearance and would not cut

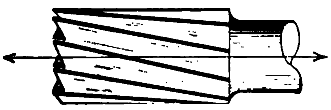

FIG. 258.

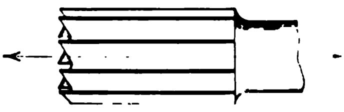

FIG. 259.

freely. For end-cutting, the ordinary straight teeth shown in Fig. 259 are more suitable, and in some cases a right-hand cutter with a left-hand spiral would be best of all (see Fig. 260). This gives correct clearance to the end teeth, and when used under favorable conditions such a cutter has no more tendency to leave its socket than a twist-drill, which is made on exactly the same principle.

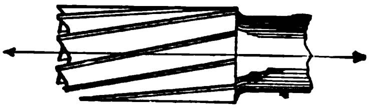
FIG. 260.

SIDE CLEARANCE.

Standard cutters frequently give trouble in the matter of side clearance. It is assumed that the cutter must not lose its width on resharpening, but there must be some dishing on the sides, or it would be unworkable; accordingly a very slight clearance is given, say one-half degree each side, which will cause the cutter to become two-thousandths (0.002) thinner when $\frac{1}{4}$-inch has been ground away in diameter. The cutter would be more serviceable if it had, say, one degree clearance each side, but that would cause it to lose its width too soon. Now suppose a quantity of work is required where the width of groove is not particular to one-fiftieth (0.02) of an inch, or where the cutter is only used for roughing, it would be worth while to take a standard cutter and grind extra clearance on it. This is particularly the case when cutting brass, which is very liable to bind on the sides.

INSERTED TOOTH-CUTTERS.

The time has now arrived when a great development should take place in the direction of cutters with inserted teeth. The obvious advantages are:

1. That cheap material may be used for the body of the cutter, and the very best high-speed cutting-steel for the blades.
2. Hardening difficulties are reduced to a minimum.
3. When worn out the blades may be replaced at a small expense.

The great objection is the first cost, particularly in the case of cutters less than about seven-inch diameter. Also inserted blades are usually not very suitable for wide cuts. The superiority of the inserted tooth-cutter is most unquestionable in the case of side- or straddle-mills which are mainly cutting on the corners.

One widely used method of holding the blades is shown in Fig. 261. The blade *A* is ground on the sides. The bush *B* is turned parallel and has a flat milled on it at an angle with the centre line. This bush, which fits in a recess, as shown, is simply a wedge and is knocked in. There is a screw *C* to prevent it coming loose. A second screw *D*, a patent one, is shown for adjusting the blades sidewise. There seems to be no reason why these cutters should not largely displace solid side-mills except in the smaller sizes.

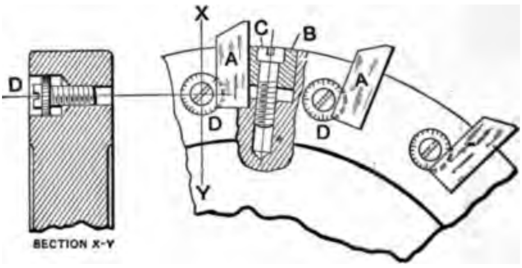

FIG. 261.

LIMITS OF INACCURACY.

Coming now to the manufacture in quantities of cutters, the great principle of "good enough" asserts itself. It must first be determined exactly what "good enough" is, and the drawing must show that exactly. Any time spent in making a measurement nearer to a dead size than is called for is a loss. Fig. 262 is a working drawing of a simple cutter which is to be measured with the micrometer, and not with limit-gauges.

According to this drawing, it has been determined that if error in the thickness of a ½-inch cutter does not exceed one-thousandth (0.001) of an inch, it is good enough. This is clearly shown, and the grinder must adhere to the limits given, but must not waste time in making every ½-inch cutter to within one-half thousandth (0.0005) of the nominal size.

Again, it has been found that about one-hundredth (0.01) is a reasonable allowance for cleaning out the turning marks on the sides after hardening. It is, however, quicker to grind off a few extra thousandths than to turn them off, and the lathesman must keep within the limits—ten to fifteen thousandths above ½-inch. $\frac{0.515}{0.510}$. He has no excuse for leaving too much or too little for grinding, nor yet for wasting time by taking a cut of two thousandths (0.002) off the side.

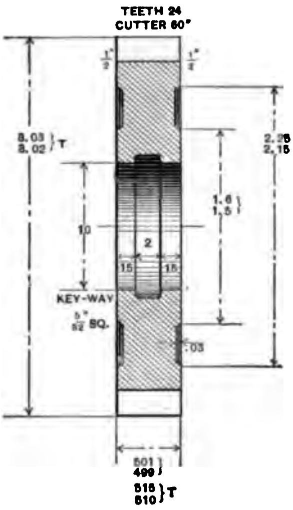

FIG. 262.

It is shown that the actual diameter is not important, and the lathesman has a limit of one-hundredth (0.01) of an inch, which means that the grinder must just clean out the turning marks.

The drawing shows that the side recesses may vary in diameter by one-tenth (0.1) of an inch. The clearance each side is stated as one-half degree, and it is essential that this shall run out to the extreme tips of the teeth.

USE AND ABUSE OF CUTTERS.

A whole chapter might well be devoted to the use, abuse, and maintenance of milling cutters. A slight reference only can be made to this branch in a chapter dealing mainly with their design and manufacture.

It is a source of great satisfaction to the maker that when a cutter is broken by being run backwards on to the work, the breakage is characteristic. A cutter may be taken that has been spoilt in this way, and although the man who broke it will be absolutely sure that it ran in the right direction, the cracks down the faces of the teeth tell a different story.

On many operations it is of the first importance to have a full flood of lubricant; a trickle is not sufficient.

REGRINDING.

It cannot be too strongly insisted that it is very wasteful to use a dull cutter. It is as hopeless to mill successfully without adequate grinding arrangements as it would be to turn satisfactorily with only the door-step to sharpen the tools on. When a cutter is changed in time, the sharpening should only occupy a very few minutes for most small sizes. If run too long, the grinding becomes a serious operation, which causes the grinder to lose his temper, and to draw the temper of the cutter.

When the resharpening cannot be accomplished by two or three passes over the emery wheel, the cutter should be mounted on a mandrel and ground whilst revolving until the worn part has all been removed; and the tooth-by-tooth grinding should be reserved for backing off to give the cutting edge. Not only is this much the quicker way, but there is no risk of drawing the temper if ordinary care be exercised.

It must always be remembered that however good a cutter is, the cutting-edge may be so damaged by a little carelessness in grinding as to receive any degree of injury up to the point of being ruined. It is well to touch the cutting-edge with an oil-stone after grinding.

As the teeth are usually reground on a dry wheel, it is important that arrangement should be made for exhausting the dust produced. Dry grinding is now recognized as a dangerous occupation, causing lung diseases. The operation is not capable of imparting consumption itself, but it so irritates the throat and lungs as to keep them in an unhealthy condition and render them susceptible to consumption germs. For this reason the emery wheel should be enclosed, as far as possible, in a hood, and a good exhaust provided by a fan or other suitable means.

QUALITY OF STEEL TO USE FOR MILLING-CUTTERS.

The all-important question of the quality of steel to be used is too often ignored. Self-evident as it is, the fact may yet be overlooked that two cutters, one made of the best steel and one of the worst, may be identical in appearance, and the difference will only become apparent in use.

In small or complicated cutters, in which the cost of steel is only a small proportion of the total cost, the amount saved by using cheap steel is slight.

In large cutters of simple forms with little machining on them, where the cost of steel is perhaps one-third or even one-half the cost of the finished cutter, the saving effected by using a poorer quality of steel amounts to a great deal, and may reconcile the user to an inferior cutting edge. Good steel may be recut, and after the hardening the cutter should not be perceptibly inferior to a new one.

SELECTING A SET OF CUTTERS FOR A MILLING-MACHINE.

A person buying a milling-machine for general use, who has not had previous experience, is immediately confronted with the problem of cutters, and the questions are frequently asked, "What should I buy for a starter?" and "What is likely to be required for my work?" It is to this class that these suggestions are offered rather than to those who by years of experience and study are prepared to give counsel and are not in need of what I have to offer.

To begin with, do not under any circumstances buy up a lot of second-hand cutters because they can be had at a bargain, as they are liable to prove very expensive in the end for many reasons. They may be unsuited for the work, out of date in design, and will unconsciously be copied in the new cutters that are made, or they may be worn away so that further grinding is impossible and consequently useless.

AN ASSORTMENT OF MILLING-CUTTERS.

The assortment of cutters shown in Fig. 263 makes a good set to put with the new milling-machine. A wide range of work can be done with them, including the making of new cutters of almost any style or size. This set consists of two of No. 6 and one mill arbor, suitable for shell-end mills from 2¼ to 5 inches in diameter, and No. 7 illustrates an end-mill 2½ inches in diameter to fit it. The arbor has a threaded collar with tongues to fit in the slots milled in the back end of the cutter for driving it.

The screw tapped into front end of the arbor drops into the counterbore in the cutter, thus keeping out of the way of the chips and holding the cutter in place. Figs. 264 and 265 show two other styles of end-mills and arbors, each having something to recommend them. The cutters shown in the group at the right are tapped standard, and have a slot milled across the back end to fit the loose collar, which is used to force off the cutter and serve no other purpose. If desired, the cutter itself could be extended and milled to fit a wrench, the only objection being that the cutter would be slightly more expensive.

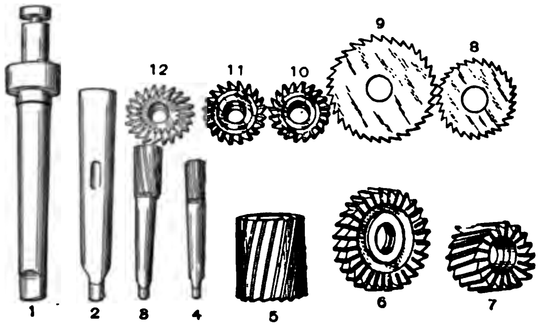

FIG. 263.

The arbor shown with cutters to fit in Fig. 264 has No. 10 B. & S. taper to fit in the machine, No. 4 Morse taper in front to fit the cutters, and Woodruff key to do the driving. It has a nut to force the cutter off and a screw to hold it on, the same as the screw in No. 1 of Fig. 263.

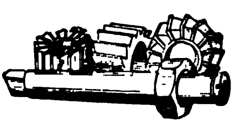

FIG. 264.

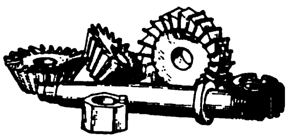

FIG. 265.

These three styles of arbors and cutters are excellent and any one of them will give good results. The threaded cutter is the cheapest because it does not require internal grinding or lapping. The taper-arbor and its cutter are perhaps slightly more expensive to make, because it is necessary that the cutter be ground internally to fit the taper. This is to be recommended when the most accurate work is required.

SHELL END-MILLS.

Shell end-mills are very useful cutters and will be largely used wherever a milling-machine is supplied with them.

Small end-mills should be made solid, perferably with taper-shanks (Nos. 3 and 4, Fig. 263), as the most accurate and satisfactory way to hold them.

SPINDLE SURFACE-MILLS.

The spindle surface-mill (No. 5, Fig. 263) is 2½ inches in diameter, 3 inches face, and is one of a great variety listed by the cutter manufacturers whose practice is to make with straight teeth where the face is less than ¾-inch wide. This style of cutter, in widths to suit, is commonly used for key-seating.

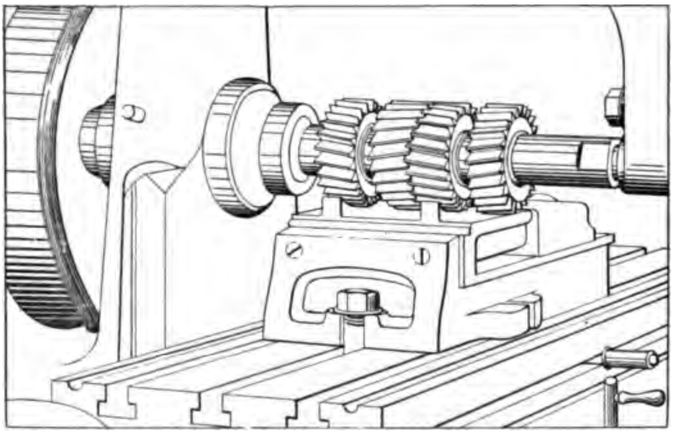

FIG. 266.

Cutters with side teeth (No. 6) could be used for key-seating, but it is obvious that they would fall below size much sooner than the cutter with outside teeth.

Teeth milled spiral will do better work on wide cuts than when milled straight, on account of the shearing out, and for heavy roughing the teeth should be nicked by cutting a coarse thread around the blank before milling the teeth.

The side-cutter is most useful in pairs for milling both sides of a piece at once, like squaring a tap-shank; the cutters operating on opposite sides of the piece take away any tendency to spring and produce accurate work rapidly.

GANG-MILLS AND INTERLOCKING CUTTERS.

A gang of spiral surface-cutters with side teeth, the inner pair made interlocking,.is shown in Fig. 266. The teeth are cut spiral, right and left hand alternately, to balance any side-thrust and to give top rake to the side teeth doing the cutting. The inner pair are made with clutch teeth to interlock; the bearing-faces being scooped out to allow the clutch teeth to engage. Paper is used to extend the cutter as the sides are ground away, maintaining a constant size and insuring interchangeability. The same cutters can also be used for roughing and finishing by taking out some of the packing while roughing, and restoring the cutters to the proper width before taking the finishing cut.

Fig. 266 shows a group of common forms. Care should be taken in grinding to have the face of the teeth radial; the tendency is to grind the point more than the base of the tooth, which places the cutting-edge at a great disadvantage.

Generally it is more economical to buy standard cutters from the maker, and in many instances special ones also, but it is at times desirable to do some of this work at home, being cheaper if the tool-room is properly equipped and organized, and the educational advantage of such work has a distinct value.

MAKING CUTTERS.

For making cutters, Nos. 10, 11, and 12 of Fig. 263 provide a good outfit. The first two have sixty degree angles, one right and one left hand, and will suffice for most straight tooth work. No: 12 is for milling spiral cutters and has twelve degree angles on one side and forty degree on the other.

Practice has shown that it is best to make cutters with radial teeth. If they are undercut so as to give the cutting-edge top-rake, as in a lathe-tool, it makes a weak tooth liable to break easily, but adds to the efficiency of heavy ones.

There is far more danger of getting too many teeth than too few into a cutter.

If the cutter is small in diameter so that it will become too thin if the teeth are deep, take the first cut through at the proper depth and then mill around again after revolving the work so as to bring the proper angle.

MOST VITAL POINT IN MILLING-MACHINE PRACTICE.

The most vital point in milling-machine practice is that cutters of whatever design be kept sharp. A dull cutter is like any other tool that is dull—its efficiency is greatly reduced, the work produced is inferior, and the cutter wears rapidly away.

The same principle applies to the cutting-edge of the milling-cutter as to any other cutting-tool for metal. If too little clearance is ground it will not cut well, and if too much, it will chatter; about three degrees will generally give good results.

SPEEDS AND FEEDS FOR MILLING-CUTTERS.

A subject upon which too much cannot be written nor thought given is that of proper speeds and feeds for milling-cutters. Often the question is asked: "What rule is there for determining the proper speeds of cutters." When a direct answer is not given to this question, the questioner is always dissatisfied and usually discouraged. Of course there is no "hard and fast" rule for determining the proper feeds and speeds of cutters, and in this book one cannot be given. The texture and hardness of the material to be machined determines the surface speed in each case. Thus, for cast-iron, a speed of forty feet per minute may be safely taken as a good basis when taking heavy roughing cuts, while for light finishing cuts on the same material, (after the scale has been removed) fifty feet per minute is not too fast. When working steel twenty feet per minute is not too fast, and for brass sixty feet per minute is a good basis for determining the correct cutting speeds for these metals.

Although the hardness and texture of the material worked upon is the chief factor to be considered when determining milling speeds, the nature of the cut and the shape are also very important factors. Thus, for instance, a large slitting-saw can be run about twice as fast as a large surface-cutter when working on the same material.

Now, with regard to the rate of feeds for milling, the most advanced practice is to take a roughing-cut with the fastest feeds the machine will pull; that is, provided the cutter is relatively as strong in comparison as the machine in which it is used. If the nature of the work requires a cutter of such a form as to be comparatively weak, it is often better economy to break an occasional cutter than to allow the machine to work at a slow rate of speed.

When running a cutter at a slow rate of speed and advancing it at a fast rate of feed on cast-iron, compressed air, delivered to the cutter with sufficient force to clear away all chips as fast as they are produced, will prolong the life of the cutter, even when the fastest feeds are fed against it. When working steel, a stream of oil on the cutter will have the same effect, providing the oil is delivered under pressure sufficient to wash away the chips entirely from the cutter.

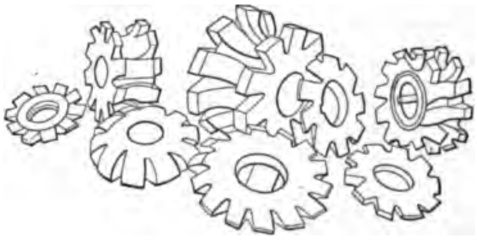

FIG. 267.

In regard to "burning" cutters, or drawing the temper while working them, it must be understood that this will not happen through too fast a feed, but it is always to be traced to too high speeds. Thus, when both speed and feed are up to the maximum, the actual rate of table travel per minute can be further increased by reducing the speed of the cutter and increasing the feed rate.

When taking finishing cuts, the rate of speed depends upon the quality and degree of finish required. Here it may be stated that experiments have determined that 0.030 per revolution of a 3½-inch cutter when surface-milling leaves a good finish, and in machine work will leave a surface that will require little scraping to make a good bearing.

Fig. 267 shows a collection of forming cutters.

To succeed with milling-cutters they should be made right, hardened properly, sharpened regularly, and speeded and fed properly.

SUGGESTIONS FOR MILLING.

Experience in the use of milling-cutters will teach anyone that unnecessary expense and annoyance may be avoided by frequent and proper grinding of milling-cutters. A dull mill will not do good work and wears away very rapidly. At the first appearance of dullness, use your cutter-grinder, it will save your cutters, your time, and your patience, and will enable the cutters to do their best and most rapid work.

In order to preserve the correct shape of formed corners, grind the teeth radially.

No definite rule can be given for speed or feed of cutters, but the usual tendency in all classes of work, except for finishing cuts, is for slow speeds and coarse feeds.

For cutting wrought-iron or steel use lard, oil, or some one of the usual compounds manufactured for this purpose.

Small mills on horizontal millers will cut better and faster than larger mills; they also cost less and will last longer.

Wherever possible use a mill that is wider than the cut to be taken.

CHAPTER XVI.

The Hardening and Tempering of Milling-Cutters.

HARDENING.

ALTHOUGH the quality of steel used for milling-cutters is of great importance the proper hardening of it is equally so. It is a fact that bad steel well treated will make better cutters than good steel poorly treated. The hardeners of such tools cannot complain of a lack of literature, as treatises and articles on the subject are continually appearing. However, practice alone can teach the details and refinements of the most interesting process in the making of milling-cutters.

In the following, methods are put forward for the proper hardening of milling cutters which are the result of experience, and while they are not necessarily the best, it is claimed that they have brought success when used.

It pays to spend time on filling blind holes, sharp internal angles, etc., with clay. In many cases asbestos should be used with wire over a weak place, or over a part which must be kept soft. The furnaces should be in a partially darkened room from which direct sunshine is excluded.

Though I have never found any disadvantage in using cold water for quenching, it is quite reasonable to suppose that water containing a considerable amount of air dissolved in it may not cool the cutter so uniformly as it would do if the air had been expelled, and therefore boiled water is to be preferred.

After machining, tools should have a few days rest before hardening. If they must be hardened immediately, they should be annealed first, but care must be taken to prevent a tendency for the surface to become decarbonized. To accomplish this, an excess of charcoal should be kept near the cutters in the furnace to maintain a reducing atmosphere.

HEATING.

It is not only necessary that the cutter should be at the right heat, and at a uniform heat, when plunged, *but it must have reached that heat gradually and uniformly.* If the heat be applied gradually, the cutter may be made hotter than the correct temperature, and yet not crack. If a crack appear under these circumstances, it will probably go through the cutter. If a cutter, after being heated too rapidly, or allowed to get much too hot, be carefully brought to the right temperature in the furnace and then plunged, the teeth may clink off. They are certain to do so if it be not nearly uniform in temperature at the time of plunging. In case of a mistake in heating, a cutter should be allowed to cool out, and heated fresh.

PLUNGING.

The manner of plunging is worth attention. A thin cutter should be in a vertical plane when it enters the water. If it were plunged horizontally, one side would be cooled before the other, and would cause the cutter to warp. A cutter with a long hole should be plunged into the bath with the hole vertical, to allow the water to circulate freely. Cutters with large recesses should be plunged with the recess uppermost—to allow the steam to escape. The object generally is, in the first place, to cool symmetrical parts simultaneously; and, secondly, to let the water have free access to every part without delay. Thus a long thin reamer should obviously be dipped endwise, in order that all the flutes may cool simultaneously, notwithstanding the fact that the water would come into contact with every part in a shorter time if it were dipped horizontally.

Cutters need not be cooled right out in the water. They may be removed as soon as they are so far chilled that the temper color would barely show if they were polished immediately. Cutters of a few pounds weight may be lifted from the water as soon as the teeth are chilled. In a few minutes the heat from the inside begins to reheat the teeth, and just before the color shows they must be plunged again for a second or two. This may be repeated three or four times or more, according to the size of the cutters. When at last they are cool enough, they should be maintained for a few minutes at a heat sufficient to just show color—a light straw—and then allowed to cool out in the air. In order to see the color, it will be necessary to have another piece with a clean surface for comparison.

WARPING.

Change in shape in hardening may be largely prevented by previous annealing, by keeping to the very lowest temperature that will give sufficient hardness, and by the utmost uniformity of heat in every part.

LEAD BATH.

Long thin reamers may be uniformly heated in red-hot lead. It is, however, important, in order to prevent the lead from being cooled by the immersion of cold articles, and also to avoid injury to the articles themselves by too sudden heating, that reamers or other articles should be independently heated to a red just below the hardening temperature, and the lead bath should be reserved for the final heating, the lead should be that sold as "chemically pure," and when in use there should be a great abundance of small charcoal floating on the surface to prevent the formation of dross which would cling to the teeth.

DEGREE OF HARDNESS.

Whether heated in lead or not, the teeth of a finished cutter should be as hard as a good, new, smooth file. They should scratch glass.

INJURY IN HARDENING.

It has been stated above that steel may be overheated, and yet not crack if the heat be very uniform. This point must be strongly insisted upon, and claims careful attention. It means that we must not regard breakage as a dividing point between good and bad hardening. It is the division between bad and worse. When steel is badly treated, it will lose its best proportion long before the treatment is so very bad as to cause actual rupture. If in a large hardening a considerable quantity of tools are broken, it is probable that many of the remainder are as bad as they can be without actually breaking; but if none are broken it is reasonable to assume that many are well hardened. A good hardener need not be afraid of occasionally getting a cutter barely hard enough or just doubtful in hardness, because a heat which accomplishes this will do the steel no harm, and it may be rehardened; meanwhile the operator has the satisfaction of knowing that the remainder of the day's work is probably very accurate indeed.

There are then two extremes which are unquestionable. A cutter which on the one hand is not hard enough, or on the other hand is broken, evidently cannot be passed.

TEST OF HARDENING.

As steel may be between these obvious limits and yet be damaged, a finer test is demanded, for if the hardener is to hit the exact point he must know exactly what success he has.

SAND-BLASTING.

For this purpose the following method has frequently been adopted with success. After being hardened and tempered in the usual manner, the cutters are dipped in oil and then sand-blasted. If there has been any overheating in the furnace, though not enough to do any apparent harm, cracks will appear on the faces of the teeth. These cracks, which are best seen immediately after sand-blasting, are frequently so small that they cannot be detected by ordinary means, and if the teeth are broken off the breakage will probably not follow them. A cutter on which the sand-blast reveals numerous cracks may still be quite passable—indeed, it would have been considered perfect but for this test. Here is a means of trying the work of the hardener between narrower limits, and he has a warning that he is giving too much fire before a tool is spoilt.

The sand-blasted cutter also possesses another advantage of some importance in the fact that if the temper be drawn in grinding sufficiently to cause any discoloration, the tell-tale line will show distinctly on the face of the tooth, and cannot be removed by another pass along the wheel.

HEATING AND HARDENING LARGE CUTTERS.

The following method of getting a good uniform test on a large cutter, say about 9 inches diameter and 2½ inches thick, in an ordinary blacksmith fire is over good, and if followed out carefully will result in perfect satisfaction.

After getting a good deep fire, with plenty of well-coked blacksmith's coal as a foundation, and having the sides of the fire well banked up with fresh coal, the cutter should be placed in the fire and covered over with "live" coals of coke and the whole brought up slowly until the cutter begins to show some red.

Then place some dry pine boards, about one inch thick, over the top of the fire and almost entirely shut the blast off. The boards of course will take fire and soon become live coals. The cutter should then be turned over and a second layer of boards placed over the fire.

By the time these are burned to good live coals we will have a thorough, uniform heat. Then after a slight application of the blast, so as to be sure to quench on a rising heat, and two or three turnings of the cutter in the fire, in order to keep the heat uniform, the cutter will be ready to quench.

This may be done in "brine," allowing the tool to remain in the bath about fifty seconds. Then quickly withdraw it and place it in a tank of oil to finish cooling. The heating should take about thirty-five minutes.

Although a good gas furnace should be used for such a job as the above, I realize that this is not always to be had when wanted.

Finally, of hardening, it may be said that it is the most difficult and the most interesting part of cutter-making.

CHAPTER XVII.

Drills and Drilling, Forming-Tools, Facing-Tools, Counterbores, Boring-Bars and Reamers.

BORING-BARS AND REAMERS.

In this chapter will be found much information, compiled from personal experience, the columns of technical journals and notebooks of fellow mechanics—which will assist the tool-maker in the designing and constructing of any special small tools which may be required for special work in the line of drilling, counter-boring and boring.

DEEP-HOLE DRILLING.

*The process of drilling deep holes in metal is a familiar one in many shops, particularly where firearms are manufactured or heavy ordnance is constructed. Since the adoption of hollow spindles for lathes and other machine tools, the methods for machining the bores of guns have been employed in machine-tool shops for drilling these spindles; and through this and the other means the principles of the operation have become better understood. It is not an easy matter, however, even with the best appliance, to drill or bore a deep hole, smooth and round, of exactly the required diameter from end to end, and perfectly straight. While many mechanics are familiar in a general way with the methods and tools for doing this work, some specific information upon the subject will be appreciated by those who have not had actual experience in deep-hole drilling.

It is known that a long or deep hole—that is, one long in proportion to its diameter—is best roughed out and finished by using a tool on the end of a long bar, which enters the work from one end. This is true whether drilling into solid metal or boring and reaming a hole that has already been drilled or bored

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* "Machinery."

out. A boring-bar which extends through the piece and on which is either a stationary or a travelling head, is not satisfactory for very long work, owing to the spring and deflection of the bar, which is made worse by the fact that the bar must be enough smaller than the bore to allow room for the cutter-head. While a long hole may sometimes be finished satisfactorily by means of such a boring-bar, by packing the cutter-head with wooden blocks which just fill the part of the bore that has been machined and so support the bar, the method is fundamentally wrong for long work.

THE TWIST-DRILL.

The modern twist-drill accomplishes all that is attained by the arrangement in Fig. 268, and in addition can be ground without seriously affecting the rake, and will free itself from chips more readily, owing to its spiral flutes. The lands of a twist-drill present a large cylindrical surface to bear against the sides of the hole and take the side-thrust. If the drill is also guided by a hardened bushing, at the point where it enters the metal, as in the case of jig work, the drill will have very little chance to deflect and the hole will be accurately located and will be quite true and straight.

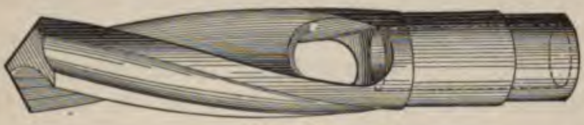

FIG. 268.

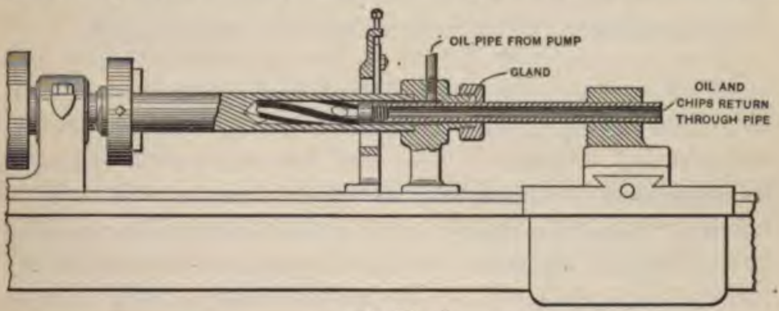

FIG. 269.

The twist-drill in modified form is also employed for deep hole drilling. The hollow drill shown in Fig. 268, and introduced by the Morse Twist-Drill Co., New Bedford, Mass., is adapted for this purpose, and in Fig. 269 is the arrangement recommended by this company for feeding the drill into the work. The drill has a hole lengthwise through the shank, connecting with the grooves in the drill. The shank can be threaded and fitted to a metal tube which acts as a boring-bar and through which the chips and oil may pass from the point of the drill. Oil is conveyed to the point on the outside of the tube, as shown in Fig. 269.

In using the hollow drill the hole is first started by means of a short drill of the size of hole desired, and drilled to a depth equal to the length of the hollow drill to be employed. The body of the hollow drill acts as a stuffing, compelling the oil to follow the grooves and the chips to fall out through the hollow shank. The methods of supporting and driving the work, and of feeding the drill, are clearly shown in Fig. 269. Drills of this type are regularly manufactured in sizes up to three inches in diameter by the Morse Twist-Drill Co. It is stated that the best results are obtained when drilling crucible steel by revolving the drill twenty feet per minute, with a feed of 0.0025-inch per revolution, while machine steel will admit of a speed of forty feet per minute, and a feed of 0.0035-inch per revolution.

NUMBER OF CUTTING-EDGES DESIRABLE.

When drilling a hole out of solid stock, some type of drill having two lips or cutting-edges is usually the most feasible, and probably nothing will be devised that on the whole surpasses the twist-drill for such work. An end-mill can be used for drilling if it has a "centre cut," and it will presently be explained how a tool with a single cutting-edge may be advantageously employed, particularly for deep-hole drilling. The familiar D-drill is of this type, and also its modification as used by Pratt & Whitney, in drilling gun-barrels.

When it comes to truing up or enlarging a hole previously drilled or bored, the two-lip drill is not suitable in any of its forms. For boring a true hole, nothing can surpass a single-pointed boring-tool, the ideal condition for finishing a hole being when the cutting-point is a real diamond, or a rotating wheel of abrasive material.

It is obvious that when a hard or soft spot is encountered in boring with a tool having a single cutting-edge, only that particular place is affected by the spring of the tool; while with a double-cutter, as shown in Fig. 270, any deflection due to irregularities, such as at *a* or *b*, will cause the tool to spring and the cutting-edge on the opposite side to introduce similar irregularities in the opposite side of the hole. This is one objection to the two-lip drill for accurate work.

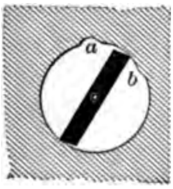

FIG. 270.

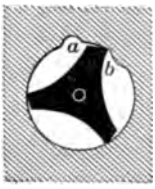

FIG. 271.

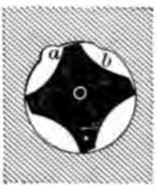

FIG. 272.

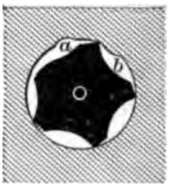

FIG. 273.

With three points the tool is somewhat better supported when a high place is countered, as at Fig. 271, and when a cutting-point strikes a low place, the other two edges are not moved away from their position so much, if they are opposite the first edge. Hence a tool with three edges should prove better than one with two, and one with four, Fig. 272, being better supported, is better on this account than one with three, but has the disadvantage of opposite cutters. Five edges, Fig. 273, ought to give even better results.

In general it may be said that in boring the best results are obtained when the tool has a single cutting-edge, but if it is desirable to have more cutting-edges, a tool with several will be more satisfactory than one with only two. Any machinist who has tried to true up the taper hole in a lathe-spindle, first by boring and then by reaming, will appreciate the superiority of the boring-tool over the multiblade reamer. A reamer sometimes refuses to produce a perfectly round hole and will do this whether the number of teeth is odd or even, and this can only be prevented by spacing unequally or "staggering."

ADVANTAGES OF THE END-CUT.

One trouble with reamers, however, is that the teeth necessarily cut on their side edges instead of on their ends, and the whole effect of any unevenness in the hole is to crowd the reamer to one side. The same condition exists to a less extent with a flat or twist-drill where the cutting-edges are at an angle with the centre line, and the resultant of any unusual pressure is felt partly as a side-thrust and partly as an end-thrust. Now, by making a drill to cut squarely on its end, and but very little or not at all on its sides, the side-thrust is mostly done away with.

In Fig. 274 is a boring-tool, with a single cutting-edge, which cuts on its end and is capable of drilling a true hole in solid metal. It was illusfrated in the August, 1896, number of "Machinery." It consists of a round, tool-steel bar, with one end flattened and ground to form a cutting-edge, as shown. It is designed to be held in the tool-post of the lathe, in a position perpendicular to the face-plate. The inner edge, or corner of the cutting-edge, should be slightly rounded, to help support the cutter and prevent chattering, and the width *A* of the cutting-edge should be from $\frac{1}{32}$- to $\frac{1}{16}$-inch less than the radius of the hole to be drilled.

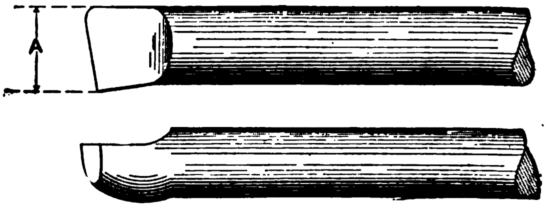

FIG. 274.

DRILLING DEEP HOLES BY THE PRATT & WHITNEY METHOD.

A highly satisfactory drill for use in drilling deep holes is one brought out by the Pratt & Whitney Co., principally for use in connection with their gun-barrel drilling-machines. The tool in question is a development of the old D or "hognose" drill, which has one cutting-lip only. It is carefully ground on the outside and is supplied with an oil-duct through which oil at high pressure may be brought direct to cutting-edge. Referring to Fig. 275, *A* is the cutting-edge, *B* the oil-duct, *C* the chip-groove.

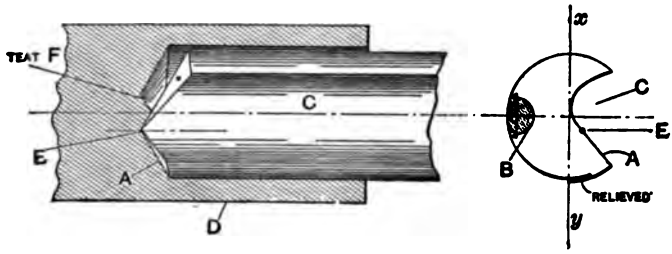

FIG. 275.

In the milling the latter groove is brought directly to the centre, so that in this respect the drill is very free-cutting as compared with the ordinary two-lip twist-drill, which has a central web. In the end view the shape of the chip-groove is clearly indicated. The cutting-edge *A* is radial and the bottom of the groove touches the centre line $x\ y$.

In sharpening the drill the high point, or part first entering the work, is not in the centre, as is usually the case in drills, but as per Fig. 275, in which *D* is a cross-section of work being drilled and *E* the high point of drill. Grinding the drill in this manner is one of the reasons for its running true or straight, the teat *F* on the work acting as a support to the drill, which, owing to its periphery being partly relieved, would have a tendency to travel in a curve away from its cutting-side. The piece being drilled is run at very high speed, the periphery speed at the outer diameter of the hole running as high as 130 feet per minute on machine steel. The feed, however, is quite fine.

These tools are made of high-grade steel and left very hard, so that the fine feed has little tendency to glaze the cutting-edge.

In practice, the piece being drilled is held and revolved at one end by a suitable chuck on the live spindle of the machine, while the other end, which should be turned perfectly true, runs in a stationary bushing having at its outer end a hole of the diameter of the drill. The drill enters the work through the bushing and is thus started perfectly true. See Fig. 276, in which *A* represents the chuck, *B* the work, *C* the bushing, *D* the support for holding the bushing, *E* the drill.

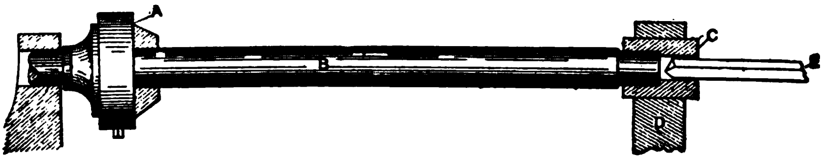

FIG. 276.

Through the oil-duct of the drill oil is forced at a pressure varying with its diameter from one hundred and fifty to two hundred pounds per square inch. After passing the cutting-edge the oil returns to the reservoir by the chip-groove *C*, Fig. 275, forcing chips along in its travel. In drills of large diameter, especially when working on tough, stringy material, the cutting-edge is usually ground so as to produce a number of shavings, instead of one the full width of the cutting-lip, so that no trouble is experienced in getting the chips out of the way. The oil, of course, is used over and over again, and with a large reservoir will be kept quite cool.

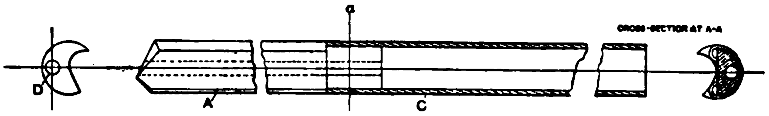

FIG. 277.

The drill is made up of the drill-tip and shank, the tip varying in length from four inches to eight inches, while the length of shank is determined by the depth of hole that is to be drilled. Fig. 277 will clearly illustrate the construction of a small, complete drill, *A* being the tip, *C* the shank, and *D* the oil-duct.

The shanks on small drills are made from steel tubing rolled as per cross-section *a a*. The tip is carefully fitted and soldered to the shank, which, it should be noted, is a little smaller in diameter than the tip. The shank, with oil under pressure, is very stiff.

The relief or clearance to the cutting-edge of the drill, the amount of "high-point" of the drill should be off centre, and the number of rings on the end of the drill depend entirely upon the material that is to be drilled. For instance, on very soft stock the supporting rest should be more substantial than on hard spindle or gun steel, so that it is evident that on soft stock the high point should be off centre, or much nearer to the outer diameter than on hard stock.

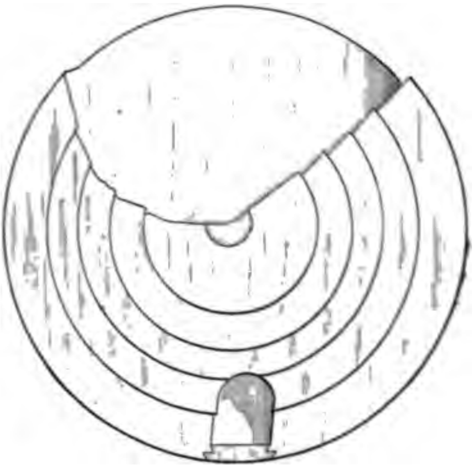

FIG. 278

Fig. 278 is a sketch of a 3-inch drill, and the reader will obtain a very clear idea from same of the appearance of the tool we have described. This figure illustrates a drill ground on the end so as to produce several shavings.

BORING HOLLOW SPINDLES WITH A HOLLOW DRILL.

*In boring the inner tubes of steel guns of large calibre, it has long been the practice to bore them with a hollow drill, which leaves a core in the centre, so that the entire metal removed is not converted into chips, but only what might be termed a shell of it, the outside diameter of this shell being practically equal to the bore and the inner diameter being enough smaller to leave a reasonable thickness for the drill.

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* "American Machinist."

At the works of Schneider & Co., at Cruesot, France, gun tubes are bored on this plan, and it is likely that the same plan is followed at Krupp's. It has not, so far as known, however, been applied to the boring of hollow spindles for machine tools until very recently, when it was found in use in the shops of Mr. Dietz in Cincinnati, Mr. Dietz's shop being operated in connection with that of the Lodge & Shipley Machine Tool Company, and upon certain sizes of their lathes. Mr. Dietz uses in a boring-machine of the usual type a drill made like the sketch, Fig. 279, which is a hollow cylinder with a $\frac{3}{16}$-inch pipe for lubrication, and the cutter is located as shown, inclined somewhat to the axial plane in order to give a top rake and with the edge gashed in order to break up the chips and allow them to be washed out through the groove from one end, and then reversed and the boring completed from the other end. This leaves a core of metal which, as it is worth a considerable amount, is well worth saving, to say nothing of the fact that the boring is more easily done and with less strain upon the machine by this plan than where all the metal is reduced to chips.

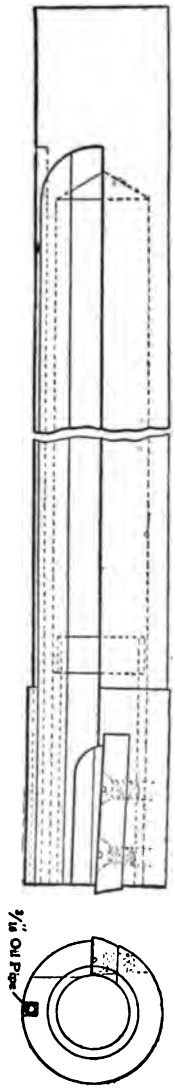


FIG. 279.

DRILL NOTES.

As a rule, the cutting-edges of twist-drills are formed with a cutter of correct form to produce a radial line of cutting-edge; thus a different form of cutter is required for milling the flutes of straight-flute drills.

Drills are generally made of 0.002-inch or 0.993-inch taper per foot for clearance, and have the major part of land on the periphery ground away for the same purpose, about 0.003-inch on a side.

Drills for brass should be made with straight flutes; those for cast-iron and tool steel should in those cases have spiral flutes at an angle of about sixteen degrees; soft steel, twenty-two degrees.

Chucking-drills, for use on cored holes, or as followers of solid twist-drills, are quite often provided with from three to eight flutes; the latter, on large work, are very efficient. Care should be taken, in grinding, to insure all teeth cutting simultaneously. These tools are made of solid, shell, and inserted type.

The inserted type are preferable for straight flutes over 2¼ inches, and for angular flutes over 4 inches, on account of cost.

For drilling a large hole in a spindle the latter should be supported in a back rest, and the drill entered through a drill-bushing to start perfectly true. Then, by using a drill with one cutting-edge and ground on the outside, a long, straight hole may be readily produced. An ordinary twist-drill will do practically the same if the centre is made female, the only objection being that this form is much more difficult to grind.

CIRCULAR FORMING-TOOLS.

Circular forming-tools for machine steel and cast-iron should have a generous amount of clearance.

Care must be taken on particular forms, when forming-cutters are not on centre, that they are formed with this point taken into consideration.

Circular threading-tools for inside threading must be much smaller than the work; about one-third is the proper practice.

Care should be exercised to use a correct angle of chaser.

PLAIN FORMING-TOOLS.

Plain forming tools should have a clearance of from six and one-half to ten degrees.

Rake: Machine steel, eight to thirteen degrees.

Rake: Tool-steel, medium, six to nine degrees.

Rake: Brass, none.

The clearance on tools for brass is quite often stoned off its cutting-edge to prevent "biting in" (due to ease in cutting) and then chattering (due to great thickness of chip and consequent difficulty in severing). The "stoning off" also tends to act as a support for the cutter.

FACING.

For steel and cast-iron, cutters with from six to twelve degrees rake cut very freely, The clearance should be from three and one-third to ten degrees; when there is any tendency to chatter, the cutting-edge should be oil-stoned on clearance-face sufficiently to prevent "biting in." On very broad work it often becomes necessary to make cutters without any rake or angle, but allow scraping, to prevent chatter.

In practice it is found advantageous to place cutter ahead of centre, exposing a larger cutting-edge to work, giving thinner chip.

In multiple or inserted cutter-heads, it is well to unevenly space the cutters; as a precaution against chattering, have the cutters "staggered."

Use machines with large bearings, and with chucks close to same, for good results.

COUNTERBORING.

For cast-iron and steel, counterbores are generally made with ten to sixteen-degree angles, *i.e.*, spiral; for brass they are cut straight. Clearance is from five to ten degrees. On brass, "stone" the clearance-edge to prevent chattering.

Counterbores internally lubricated are recommended for steel for use to depth of one-half of the diameter or more.

Angle-clearance on all tools must be more than spiral generated by feed at smallest diameter of cutting-point, plus sufficient to be really forced to work (about three degrees).

COUNTERBORES.

As a rule counterbores should be made with a hole chucked at the cutting-end several sizes below the hole that is to guide the counterboring tool.

Then the guides used at the cutting-end may be of many sizes, and fit many-sized holes. The shanks of the guides, or the ends that enter the holes, should be all of one size, and should be fitted to force lightly in so they may be readily removed from the body of the tool and others inserted in their place to fit a hole of another size. The upper portions of these guides are turned up to a shoulder, and to about half an inch or less from the outside, or according to the size of the tool. This also gives the workman a better chance to file the cutting-end or lips to a perfect and true edge. The lips on their sides may be an inch or less in length, according to their diameter, and they should be milled out diagonally in order to give a shaving cut and also a better clearance for the chips.

REAMING HOLES IN THE TURRET-LATHE.

To ream holes uniform in diameter in the turret-lathe or monitor, it is necessary that there shall be in all cases an equal amount of metal for the reamer to remove. To insure this condition two reamers, a rougher, and a finisher should be used. The hole, first, if cored, should be bored by a single or a double edge boring-tool to insure a hole comparatively true.

REAMING HOLES IN THIN DISKS.

For reaming holes in thin disks a reamer of the "rose type" should be used, as it will be self-supporting, and the possibility of enlarging the hole by its weight will be obviated.

MACHINE-REAMING WITH A "FLOATING" REAMER.

Very often, when machine-reaming, the finishing reamer is supported loosely in its holder, and allowed to find its own centre by following the true or concentric hole left by the preceding tools. This is usually done by having a "floating" reamer with a pin entered through the holder and the reamer in the back end, the hole in the reamer being made larger than the pin, thus allowing the reamer to find its own centre. The construction of a reamer of this type is shown in Fig. 280.

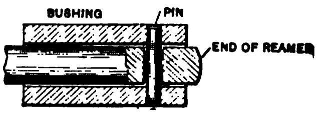


FIG. 280.

REAMING TAPER HOLES IN CAST-IRON.

For reaming taper holes in cast-iron machine parts in the turret-lathe, particularly those parts from which large amounts of stock are to be removed, a reamer of the construction shown in Fig. 281 should be used. As will be seen, this reamer has only three blades. The flutes in a reamer of this kind should be cut as deep as the diameter of the stock will allow, and the blade should be given very little clearance. The clearance that is necessary may be provided by grinding the blades convex, as shown, instead of flat or hollow, as is usually done. When a considerable amount of stock is to be removed, a reamer of this type will work very well. The preliminary work required, with regard to the other boring-tools, before the one shown should be used, consists of boring a hole to the right size for the small end of the reamer, after which the three-blade finishing reamer may be used to finish an irregular surface from three to six inches long, feeding the reamer in rapidly without danger of catching, chattering, or roughing up. In one large machine-manufacturing establishment thousands of holes are finished every day with reamers of this type, attaining the best results in the shortest time with the least trouble.

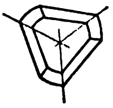


FIG. 281.

TAPER-REAMING IN THE SCREW-MACHINE.

To do taper-reaming in the screw-machine, use reamers tapering from 2¼ inches per foot upward, and the best results will be accomplished. For very accurate work the reamers will give better satisfaction if made with left-hand spiral flutes.

For want of proper grinding facilities, however, this is not done in many shops.

To ream slightly tapering holes of small diameters, the reamer should always be made with the teeth "staggered" in spacing, and each flute a left-hand spiral of different pitch.

Very often roughing-, taper-, and forming-reamers for steel are finished with an undercut. They remove material very rapidly.

REAMERS FOR PROJECTILES.

In the production of projectiles, forming-, taper-, and curving reamers are used. For this work roughing-reamers should be finished with a left-hand spiral thread nicked around, while the finishing ones should be finished straight. The finishing of taper-reamers with left-hand spiral flutes for this work prevents their being drawn in while cutting.

TAPER OF ROSE-REAMERS.

Rose-reamers should be given taper for clearance, about 0.003-inch to the foot will be enough. This will prevent them from roughing up the hole and allow of finishing holes straight and correct in diameters.

CENTRE-REAMERS.

Centre-reamers should be finished to an angle of sixty degrees, and the work centres of all machines to the same. The centres should be hardened and ground in their machines by means of a good tool-post grinder to gauge, as it is impossible to do good work on defective centres.

REAMERS FOR BABBIT.

For reaming babbit, the reamer may be of the usual form, except that the edges of the blades should be ground taper for about ½-inch from the end. Sometimes reamers for such material are finished with left-hand spiral flutes, which contributes to finishing a smooth hole free from lines and rings.

REAMING HOLES IN TWO KINDS OF METAL.

Not infrequently it is necessary to bore a hole in a part which is made up of two kinds of metal, such as brass and cast-iron, for instance. This is a rather difficult thing to accomplish successfully, as the hole will usually be larger in the softer side of the metal than in the harder. However, by using a reamer with a cutter-face of the construction shown in Fig. 282, and cutting an uneven number of staggered flutes in it, satisfactory results will be attained. Have the angle of the cutter-face about ten degrees. In using this reamer, first bore the hole with the usual type of boring-tools until it is a size slightly below that required, then chamfer the edges of the hole on the hard side and feed in the reamer, lubricating generously with oil, and always see that the hard side of the work is out.

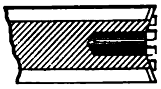


FIG. 282.

MACHINE-REAMING OF BRASS PARTS.

For the machine-reaming of brass parts some make their reamers slightly over size, but this is wrong. Instead, a reamer for brass should be ground in much the same manner as a turning-tool for brass should be—that is, in place of a radial line in the centre, as in most other reamers, the cutting-edges should be thrown off from the centre at an angle of about twenty degrees out of the radial line, as per Fig. 283. For the same reason, in turning brass, if the tool is ground straight and set central with the work, chattering is bound to occur. If, on the contrary, the tool is reground on top to an angle as described above, running toward the underside of the blade, chattering will be obviated and the tool will cut freely. Always keep the cutting-edges of reamers for brass as sharp as possible by "stoning," because as soon as the cutting-edges become slightly dulled they will bind and scream.

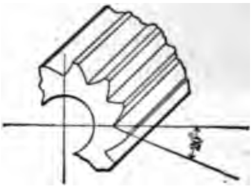


FIG. 283.

SQUARE REAMERS AND EXPANSION REAMERS.

Fine finishing of holes in brass may be done with the square reamer or "scraper." Expansion reamers also possess many good points, but few, if any, can be expanded and adjusted for sizing without the cutting-edges requiring to be ground before the tool can be used. However, there are some in which the blades will expand equally. Even if it is necessary to grind the expansion reamers when changing an adjustment, there is economy in their use when compared with the cost of a new solid reamer, especially when they are used for holes of large diameters. A long hole may be reamed straight by pulling back slightly after the reamer has commenced to cut.

REAMING SMALL HOLES.

For machining very small holes in steel and cast-iron, reamers should be ground straight, while for brass and copper they should be ground slightly back, tapering in order to eliminate the possibility of roughing up the holes.

Always remember that on reamers for steel and cast-iron the teeth should be on centre, while for brass, copper, and similar metals they should be at an angle of twenty degrees off the radial line.

Speeds for machine-reaming should usually range from 20 to 25 per cent. lower than turning and drilling-speeds.

"HOME-MADE" REAMERS.

There are in a great many shops numbers of "home-made" reamers in the possession of the men, made at various times by the mechanics, without due regard to their proper construction. Reamers of this kind should never be used for fine work, as they are usually defective. For instance, the flutes are too shallow and spaced too close, and often they are spaced evenly instead of being staggered, or they have an even number of teeth, all of which is wrong. When a reamer is evenly spaced it will chatter as soon as the cutting-edges fall into the notches left by the preceding one. A common fault with "home-made" reamers is that they are given too much clearance, thus making chattering inevitable.

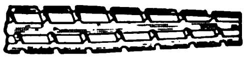


FIG. 284.

HAND-REAMING.

In hand-reaming never leave more than 0.003 of stock to be removed, no matter what the material may be. On the contrary, for machine-reaming, not less than $\frac{1}{32}$ and often $\frac{1}{16}$ should be left;

using reamers with much coarser blades than the usual commercial ones, and formed so that they can be ground on the points.

Hand-reamers for use in boiler, bridge work, etc., should be of the construction shown in Fig. 284, as they will work better than the usual half-round kind.

INCREASING THE SIZE OF A REAMER WHEN WORN.

To increase a reamer to size when worn, burnish the face of each tooth with a hardened burnisher, which can be made from a three-cornered file nicely polished on the corners. This will increase the size from two to ten thousandths in diameter. Then hone back to the required size.

To make a tap or reamer cut larger than itself, put a piece of waste in one flute, enough to crowd it over, and cut out on one side only. In larger sizes (1½-inch or over) put a strip of tin on one side and let it follow the tap through.

CHAPTER XVIII.

Broaches and Broaching.

THE OPERATION OF BROACHING.

THE operation of broaching may be classed under the head of punches and dies, as it is analogous with press-work. In reality the broach is a punch, the cored or drilled holes in the work to be machined by it acting as a die and guide for same. The operation of broaching has had great development during the last decade, special machines and forms of tools having been designed to further the use of this interesting and labor-saving process for the finishing of work which it was formerly thought to be impossible to finish by such means.

The broach as a tool is usually used for finishing holes which have been previously either punched, cored, drilled, or bored in metal, the shape of which may be round, square, or any irregular shape desired. Although the broach can be used to advantage for the finishing of holes by setting it under an ordinary power-press, an arbor-press, or a foot- or screw-press, the operation can be best accomplished in a press specially designed for the purpose of broaching. A press of this sort has usually an adjustable stroke of from 1½ to 12 inches.

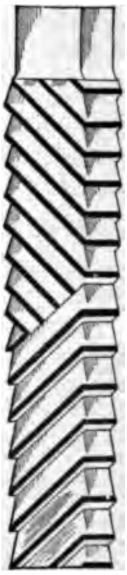


Fig. 285.

In Fig. 285 we show a sketch of a broach used for finishing a cored hole in a rough casting. The tool is 3 x 1 inches, and 9 inches in length. In this tool the teeth are very coarse at the lower end, being intended for removing the bulk of the stock until the centre of the broach is reached, when the teeth are sheared in the opposite direction, thus breaking the chip off. The teeth in the broach then decrease in size until near the upper end, when they are left the one size for about two inches of the remaining length, thus forming a "sizer" which shaves the hole to a standard size all the way through.

In forcing a broach through a hole it may be best driven by a "V" brock, which should be secured in the press-ram in much the same manner as a punch would be. Thus when the press-ram descends the broach will find its own centre; while the liability of breaking or bending the broach or producing an imperfect hole will be obviated.

In order to broach holes of considerable length in a press with a short stroke, the work may be satisfactorily accomplished by using a successive number of blocks. First insert the broach in the hole and then drive it down into the same for the full length of the press-stroke. Next, insert a block of the same thickness as the length of the stroke between the ram-face and the broach-end, and then force the broach in a further distance; repeating the operation and using larger blocks until the desired length of drive has been obtained. By this method it may be well to state that the results attained will not equal the work performed on a continuous stroke-press, as the stopping of the broach when partly through the work allows the metal to settle into the broach teeth, thus increasing the tendency to bend and break.

To-day there are on the market any number of machines which have been specially designed for broaching. A number of these machines perform the operation by pulling the broach through the hole instead of forcing it through.

AN INTERESTING JOB OF BROACHING.

Broaching is very interesting work. For some work the best and only way to make a broach is in one piece; while for other work long experience has taught that it is the wrong way. To do the job shown in the sketch, Fig. 286, with one broach would require a long one, and that would cause trouble; for a broach of sufficient length for this work is difficult to turn and mill, and to harden and draw, owing to the keyway on one side which will cause it to spring in hardening; it would be an advantage if it were grooved on opposite sides.

The hole in the piece shown in Fig. 286 is broached from $\frac{1}{2}$- to $\frac{41}{64}$-inch—and a key $\frac{1}{16}$-inch high formed—and is afterward drifted to $\frac{11}{16}$-inch at the bottom and $\frac{3}{4}$-inch at the top; the thickness of the piece is $\frac{3}{4}$-inch. Over 250,000 pieces have been made with the broaches as shown, and the loss in broaches and pieces was nothing compared with the loss when using the long broaches first made.

The stock for this job was a special tough tool steel. The broaches are shown in Figs. 287 to 291; they were four inches long and of the diameter given. Each was tapered at one end

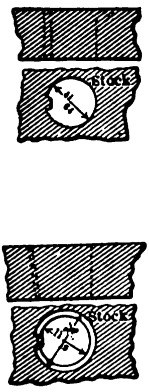


FIG. 286.

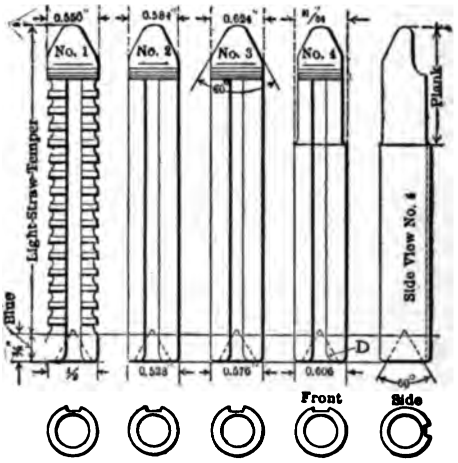


FIG. 287. FIG. 288. FIG. 289. FIG. 290. FIG. 291.

and countersunk at the other, and the top, or male end, was milled flat on one side (like No. 4) to fit the punch-press fixture, Fig. 292. Nos. 1, 2, and 3 have five teeth per inch, and No. 4 has six teeth; it will also be noticed the latter broach is left blank at one end; this will be explained later.

The teeth being $\frac{3}{8}$-inch from the end, this part was drawn to a blue after hardening. This was very important, as the end had a tendency to crumble and break out and thus destroy the broach. The end was drawn by dipping in hot lead after the broach was hardened and drawn to a straw color. For cutting tool steel very little clearance was given the teeth; too much clearance would cause the broach to cut ragged.

The ½-inch hole to receive the end of the first broach was drilled in the stock, and the other end of the broach was inserted in the hole *H* in plate *C*, Fig. 293. To the plate was secured two rods, which had a vertical movement in plate *B*, light springs keeping plate *C* away from the punch. An important feature is the hole *H*, which received the end of the broach and prevented its being placed in the wrong position, as each broach had to follow exact, owing to the keyway.

A clearance (shown at *D*) on each broach served to guide an end of the broach while entering. After the first broach was entered and forced into the work by the press, the upper end projected above the work to receive the second broach, which was in turn punched through, being followed by broach No. 3, and the latter by No. 4. If teeth were cut the full length of the last broach, it would stick in the work. To overcome this it was cleared at the end, as shown, so that when punched down to the end of the stroke the broach would fall through. The work in making broaches of this length is simple, as they are easy to turn, harden, draw, and grind.

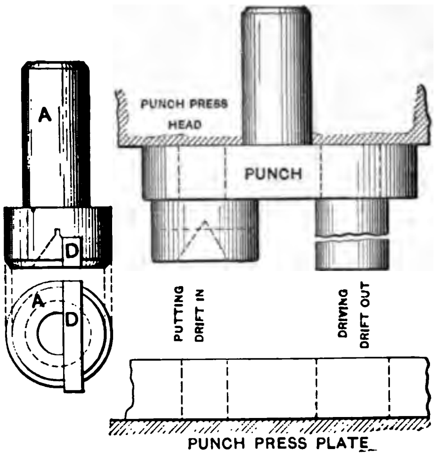


FIG. 292.

In punch *A* a hardened-steel plate, *D*, was inserted, as at this point any wear would cause the broach to twist and spoil the key. This is made a driving fit, and can be replaced at any time. The finished hole, Fig. 286, was drifted cold; and owing to the quality of the stock was a neat piece of work. Figs. 293 and 294 show the drift and the punch-press fixtures. The punch for putting in the drift had a steel insert, the same as *D* in *A*. It is very important in making broaches that the stock be thoroughly annealed, and when broaching use nothing but the very best of oil.

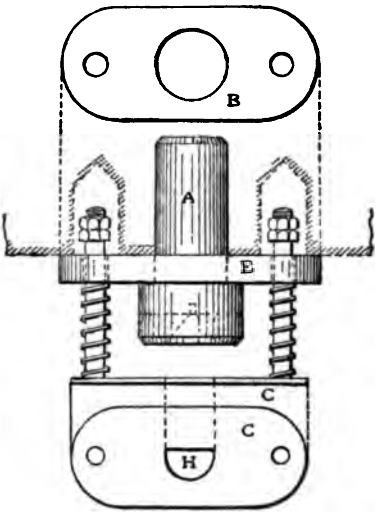


FIG. 293.

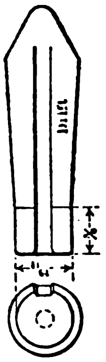


FIG. 294.

SOME POINTS ABOUT BROACHES AND BROACHING.

In order to secure good results in broaching the bottom of the tool used should be hollowed out somewhat, so that a nice clean chip will be cut from the inside of the hole, and so that the tendency to dodge to one side when places in which the cored hole is rough or crooked are encountered will be obviated. The stripper for the work should be arranged so as to pull off square. Otherwise, if the hole is a long one, it will be spoiled when the broach is pulled out.

The special presses provided for broaching are usually back-geared and very powerful. It is not well to speed the press too fast. In all cases use oil as a lubricant. When the amount of stock to be removed is considerable, it will be necessary to do the work in two operations; too heavy a cut having a tendency to make the hole rough. Socket-wrenches or similar fits are easily made in this way. If the cuts are made light enough, it is possible to broach cast-iron in this way, using for this purpose several punches or broaches of different sizes. Such punches should be slightly larger at the cutting end, and for the finishing cut or last operation—if clear through the piece—should work into a die or the tool will break off or tear away the lower edge of the work. The temper should be a trifle harder than that given to ordinary punches and dies. *A* in Fig. 295 shows a side view of a broach which was made for cutting out the holes in three cast-steel flanges for a steamboat. The holes had been cored out of a ⅝-inch bolt instead of a ¾-inch; hence the necessity for enlarging them. The broach was made with six steps, as

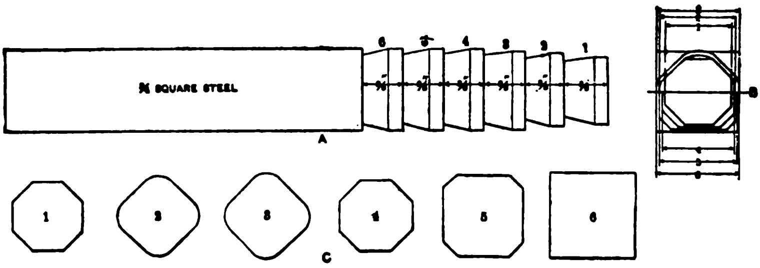


FIG. 295.

shown at *A*, and with the steps numbered at *B*. Step 1 acts as a pilot and to scrape out the sand; step 2 cuts on four sides somewhat, as shown at *C*, step 3 cuts the hole slightly larger in the same manner; the next three steps cut out the corners, as shown in 4, 5, and 6.

There were ninety holes in all, one-half of which were through metal ½-inch thick, and the other through metal ⅝-inch thick. It took about three hours to broach them out, driving the broach with a sledge, as no press was at hand. The operation of making the tool took about one and one-half hours on the milling-machine, using an end-mill.

BROACHING: ITS RELATION TO SHEET-METAL WORK.

Oberlin Smith, in his "Press Working of Metals," has given us the following in regard to the relation of the word "broaching" to sheet-metal work:

". . . The word 'broaching' has here a very different meaning from that given it by the machinist, who applies it to the process of forcing a piece of male work through a lower cutting-die, or pushing a cutting-punch through a hole in female work, thereby shaving it to a given size, and really performing an operation analogous to planing or slotting. In cases where he uses male or female broaching-cutters having a series of teeth following each other, and each taking off its own chip, his work more nearly resembles milling. In relation to sheet metals the word broaching means smashing the work thinner by forcing it through a space between the punch and die, as in some kinds of tube-drawing, which again is the same as wire-drawing, if we imagine the mandrel to be a part of the tube. In the case in question a reduction of diameter is being made at the same time as the thinning of the metal is taking place. This is much practised in cartridge-drawing, especially where it is desirable to keep the end or bottom of the work of the original thickness. When done, the bottom remains of as much greater thickness than the sides as happens to be required and as has been arranged for in choosing the thickness of the sheet. In small work of this kind the use of a blank-holder, or upper die, is abandoned after the first one or two draws, as the metal is reduced so little in diameter in proportion to its thickness that the wrinkles have no chance to form. Even if incipient wrinkles do form they are quickly crushed out again as the metal is squeezed somewhat thinner. In this, as in all drawing, however, the wrinkles must never be allowed to get big enough to fold over upon one another."

CHAPTER XIX.

Shop Use of Micrometer-Calipers and the Height-Gauge.

MICROMETER-CALIPERS.

In the accurate production of duplicate parts as carried on to-day in the economic manufacture of machinery, tools, punches and dies, and instruments of precision, accurate gauges are demanded. For years the average machine-shop got along with templets and gauges of sheet steel, so-called "limit-gauges," of doubtful accuracy and of little value, as they were carelessly made and used with indifference. However, we are pleased to say, this state of affairs has passed away; and the increased use of the micrometer-caliper has enriched the scrap piles of many shops with collections of "snap" and "limit" gauges, "templets" and "reference" disks; has increased the economic production of the shops, and made the workmen more skilful.

To produce accurate work the skilled machinist or tool-maker of to-day demands as a first requisite a means of measuring his work during the process of machining it to the required size and shape; and this requirement is filled when the workman is supplied with a micrometer caliper and the feed-screws of the machine which he operates are fitted with graduated disks. Of course it must not be inferred from this that brains are not required along with these gauges; or that an indifferent or careless workman will instantly become a skilled mechanic upon being supplied with a micrometer. However, the use of the micrometer will improve the poorest workman; as instead of guessing he will measure; he will use his eyes and think; thus a consequent improvement will take place.

Among shop managers, superintendents, and foremen, the most common objection raised against the general shop use of micrometers is that they are too light, and are liable to get out of order when used by all classes of help. Now, while this may occur, there is hardly any excuse for it; any man that is trusted with and is capable of turning out accurate work can be safely trusted to use a micrometer correctly. To be sure it makes a great difference *how* the tool is handled. It all depends upon the workman's sense of touch. The machinist, as a rule, wants information as to how much more has to come off after he has taken a cut, and so he sometimes forces the gauge in the hope of determining by the sense of touch how much remains to come off. This sense of touch differs in mechanics very much. In some it amounts to a considerable exertion of their strength; these are the one who spoil the gauges.

With the micrometer there is no excuse for the use of strength; it is an adjustable gauge and the machinist knows by reading it when the work has been reduced to the size desired. He knows also that he may run the screw back at intervals and determine the amounts remaining to come off; he may also determine the size at the start; and for sizing a number of pieces he may lock it and use it in the same manner as he would a snap-gauge. In the use of the micrometer the mechanic has to use his eyes and brains more, and his strength becomes an ineffective factor in the attainment of the results.

It is very easy to teach bright apprentices and operators how to use micrometers; in fact, the reading of them to the one-thousandth of an inch is very simple; while their reading to one-ten-thousandth of an inch can be learned after a little thought and practice. The ease with which workmen in general learn to read and use these gauges can be inferred from the fact that there are any number of small shops—in the East at least—to my knowledge, in which accurate work is turned out, where nothing in the way of gauges is used but micrometers. As this is successfully done on a small scale, I can see no reason why the installation of the system on a large scale should present difficulties.

In all shops in which micrometers are used in place of the obsolete gauges, or in shops where they are about to be used, a good set of B. & S. test pieces, either end-measures or disks, should be provided; also a man should be detailed to take care of the adjustments of all micrometers in the shop; someone who is skilled in such work and who has cultivated a delicate sense of touch. In shops where the work done is of great accuracy and only the minimum limit of error is allowable, two sets of test measures should be provided; one set to be for general use and the other for occasional reference only. The new micrometers should be given to the most skilled men for use on the finest work only; while those micrometers that have become worn, or are to a certain extent inaccurate, should be used on work in which a greater limit of error is allowable. Above all, never use generally calipers graduated to ten-thousandths, where fine measurements are not necessary, as in an instrument of the precision of this class a wear is preceptible and important which would be of comparatively slight consequence in a caliper that is graduated to be read only in thousandths.

READING MICROMETER-CALIPERS TO TEN-THOUSANDTHS OF AN INCH.

While the ordinary reading of micrometers is pretty generally understood—*i.e.*, reading to thousandths of an inch—the reading of them to ten-thousandths is not. For the benefit of those who do not understand this I explain in the following how to do it.

In Fig. 296 a 1-inch B. & S. micrometer-caliper graduated to read to ten-thousandths of an inch is illustrated. The readings in ten-thousandths are obtained by means of a veriner or series of divisions on the barrel of the caliper on the side shown in the cut. These divisions are ten in number, and occupy the same

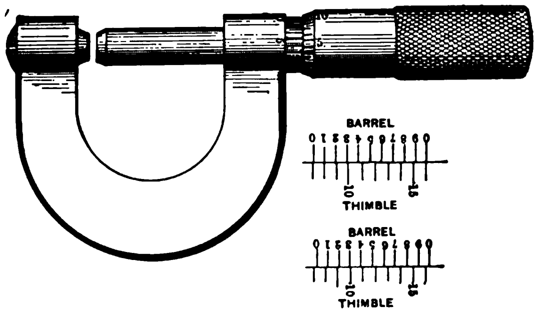


FIG. 296.

space as nine divisions on the thimble. Accordingly, when a line on the thimble coincides with the first line of the veriner, the next two lines to the right differ from each other one-tenth of the length of a division on the thimble; the next two lines differ by two-tenths, etc. Note the left hand cut of graduations on the barrel and thimble in Fig. 296.

When the caliper is opened, the thimble is turned to the left, and when a division passes a fixed point on the barrel, it shows the caliper has been opened one-thousandth of an inch. Hence, when the thimble is turned so that a line on the thimble coincides with the second line (end of first division) of the veriner, the thimble has moved one-tenth of one-thousandth, or one ten-thousandth of an inch. When a line on the thimble coincides with the third line (end of second division) on the veriner, the caliper has been opened two ten-thousandths of an inch, etc. Note the right hand cut of graduations, where the line on the thimble coincides with the fourth line (end of third division) and the reading is three one-thousandths of an inch.

To read the caliper, note the thousandths as usual, then count the number of divisions on the veriner, commencing at the left, until a line is reached with which a line on the thimble coincides. If the second line, add one ten-thousandth, if the third, two ten-thousandths, etc.

SPECIAL USES OF MICROMETER-CALIPERS.

Besides the uses for which the micrometer was primarily designed and is generally used, there are any number of special uses to which the caliper can be put: In the following I enumerate and describe a number which will no doubt be the means of suggesting many others.

In order to determine whether the dead centre and the live centre of a lathe are in line: First, set the centres as near as possible by eye; then carefully centre a piece of stock about six inches long; place it on the centre and turn one end for a distance of about one-half inch, using a sharp-edged tool so as to get a smooth surface. Then reverse the stock so that the turned end will be at the live centre. Next, turn the other end to exactly the same diameter, using the micrometer to gauge it. Now clamp the micrometer to the cross-slide of the lathe, so that the end of the barrel or ratchet-stop will rest against the work, as shown in Fig. 297. You can now set your centres *accurately* by running the barrel out against the nearest end, noting the reading and running back the barrel, running the carriage up to the other end and repeating the operation. A few trials and adjustments of the tail-centre and both centres will be set dead in line.

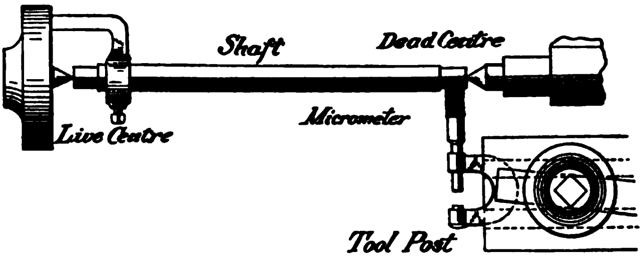


FIG. 297.

In order to test the lathe to see whether the centres are the same height from the ways, the same method can be adopted by using the micrometer backward, from the top down, or from the bottom up, as shown in Fig. 298.

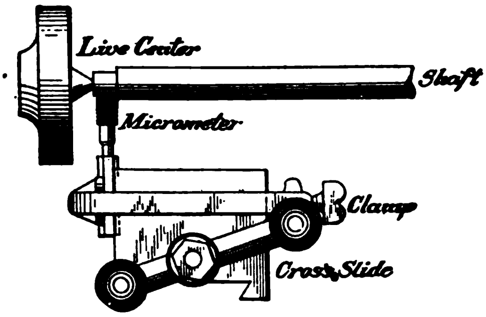


FIG. 298.

To line up the centres on a grinder so as to get them dead in line the micrometer can be used by fastening the caliper between the collars of the spindle where the emery-wheel is usually located, in the manner shown in Fig. 299, and by blocking up the spindle in the most convenient manner. In using the micrometer in this manner, however, always remember that all round or circular work will have an error twice that evidenced by the gauge.

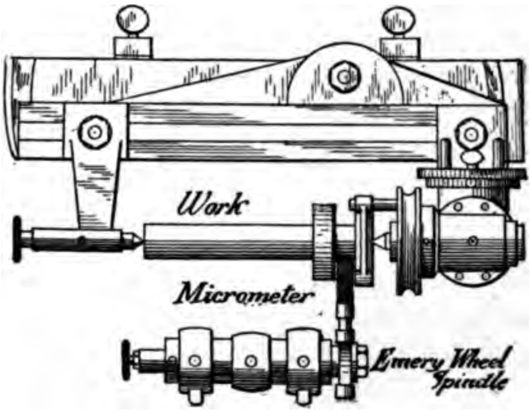


FIG. 299.

That is to say, if the centres show only 0.0012 by the micrometer in the test, they will shown an error of 0.0024 on the work. On straight surface work the test will show the actual error.

It will be at once obvious to the practical reader that this system of testing can be applied to almost any machine in the shop. On the planer, miller, shaper, or precision-lathe it will be found all that can be desired in detecting errors in the platen, vise, or fixtures; while when utilized in the lining up of a job with a finished surface, it is as good as a surface-tester and lends itself much more readily to the work in hand. In fact, this system can be almost universally applied where accurate work from machines is absolutely required.

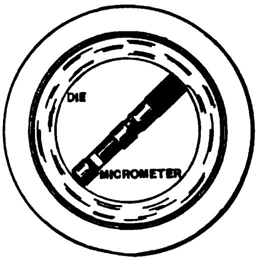


FIG. 300.

The micrometer-caliper can also be used as an inside caliper in any hole in which it will go in with ease. This is shown in Fig. 300, the caliper being used to gauge the inside of a large cutting-die when grinding it to the finish size. To use the gauge in this manner it is only necessary for one to learn to read the graduations backwards; then no difficulty will be experienced in using it as an inside micrometer.

In all shops where micrometers are used generally it will faciliate their use and expedite the production of accurate work by having the feed-screws of all machines fitted with graduated dials; and if the micrometers in use are graduated to read in thousandths, by having the dials to read the same.

The universal use of micrometer-calipers for regular machine-shop gauges is not far distant, as it will not be long before the chief and perhaps the only interdiction to their extensive use—their cost—will be overcome. That the demand is growing is evidenced by the fact that one concern in the East manufactures a line measuring from six to twelve inches for use on the larger classes of interchangeable machine work.

THE HEIGHT-GAUGE AND ITS USE.

While the micrometer occupies first place among the small precision tools of the universal shop, there is another tool which follows it a close second. I refer to the height gauge, Fig. 301; a tool that although it is used quite generally among tool-makers, is comparatively unknown outside of them. If more were known of the great utility of this handy, accurate, reliable, and almost indispensable tool, its use would become common in all shops where accurate work is done. By many the height-gauge is thought to be merely an accessary to the tool-maker's kit, and of no use except in verifying measurements; when, on the contrary, it can be used for a thousand and one jobs in the attainment of results with ease which would otherwise be almost impossible of attainment were other means used. In accurate work, especially, by means of the height-gauge, jobs that appear to present insurmountable difficulties are accomplished with ease.

In order that the utility and value of this accurate tool may become better understood I will present a few examples of its use:

By far the most usual and common method of striking or scribing a line on a piece of work is with the surface-gauge; setting the scriber to some graduation on a scale. This method, however, is not to be compared with the height-gauge and its scriber in point of economy of time, labor, and worry; for the reason that the height-gauge may be set almost instantly and accurately when one is familiar with it, and a line may be scribed with it at once with the assurance positive that it is in *exactly* the place that one wishes it to be. With the surface-gauge the scriber must be raised and lowered many times before the correct (?) height is obtained; even then the final setting is a guess.

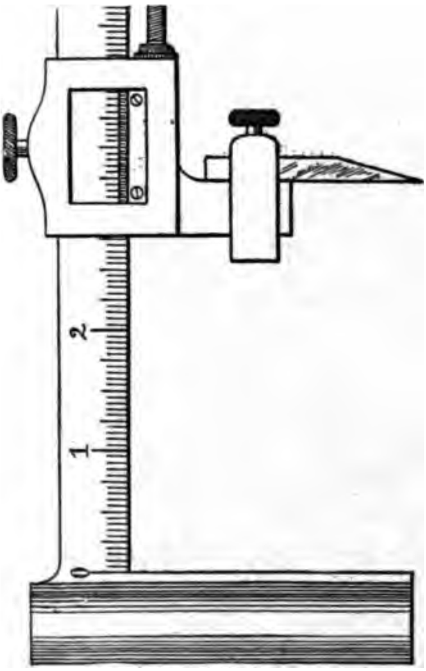


FIG. 301.

For example second, let us say that it is necessary to locate eight holes in a circular finished casting as per Fig. 303; the holes to form the corners of two squares, one within the other, with the four holes of each equidistant from the centre of the casting. The way to accomplish the desired results accurately with ease will be to take an angle-plate like 302, true it on three of its sides, and then clamp the disk on its face *A*. The exact diameter of the casting in which the holes are to be located is found first; then the height of its lower edge from the surface-plate on which the angle-plate rests; then, by means of the veriner on the height-gauge and the scriber which comes with it, we scribe two lines the required distance apart, equally above and below the centre, for the outside square, then two more lines for the inside square. Next, without removing the casting from the angle-plate, we turn the plate on to face *B* and then scribe four lines in a like manner, thus finishing the two squares. All

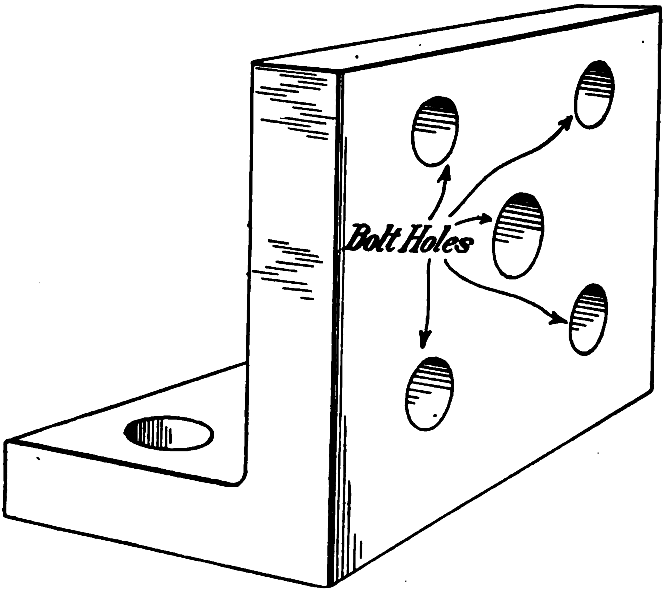


FIG. 302.

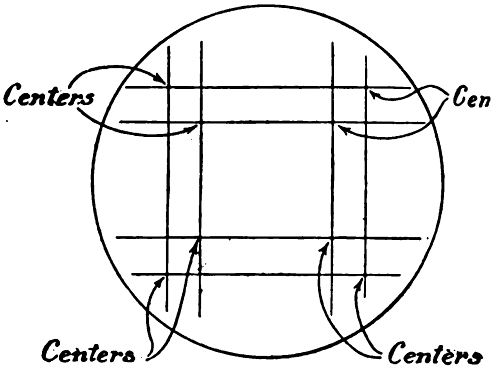


FIG. 303.

is now ready to drill and tap the eight holes approximately correct, where the lines intersect, for the "button" screws, which we use to locate the "buttons" true for boring the holes. From this example it will be at once obvious that holes may be located in a like manner on any given surface, providing that care has been previously taken to have the surfaces from which the necessary measurements are taken perfectly true and square with each other.

For the third example, we will take the block shown in Fig. 304, which has a hole at *C* and in which it is desired to drill two more holes centrally with the first one way, but at angles with it the other, as shown by the dotted lines. We first bolt the angle-plate on the table of the miller, square with the spindle,

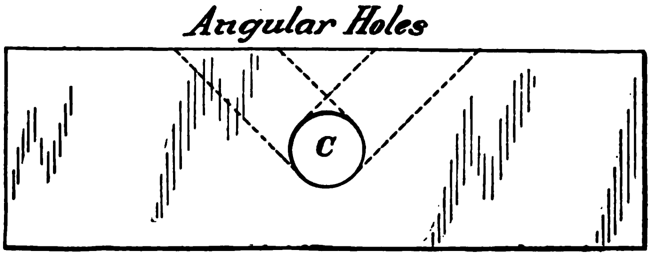


FIG. 304.

and then fasten the block to the angle-plate, at the required angle with the table. We locate a plug in the hole first drilled at *C*, as shown in Fig. 305, and then find with the height-gauge the exact distance the centre of the hole is from the table. Then, with a plug in the miller-spindle—which must run perfectly true—we measure from the plug to the table, raise or lower the knee until the centre of the spindle is the same distance from the table that the centre of the plug in hole *C* is, setting it horizontally, by measuring from the plug in the spindle to the angle-plate, or the edge of the block to be drilled, with the height-gauge. We have now everything ready to bore one of the angular holes; which may be accomplished by using a draw-in collet end-mill, or a single-pointed boring-tool, to finish the hole. The other hole may then be finished in the same manner by reversing the block on the angle-plate and proceeding as before.

In conclusion I may state that experience has proved that more accurate and expeditious results can be obtained with the height-gauge than the surface-gauge. Lay out your work with the height-gauge; prickpunch carefully where the lines intersect —using a glass where unusual accuracy is essential—and indicate carefully on the lathe face-plate; drill the hole, and finish it by boring. In this manner you will get as near perfect accuracy as it is possible to get.

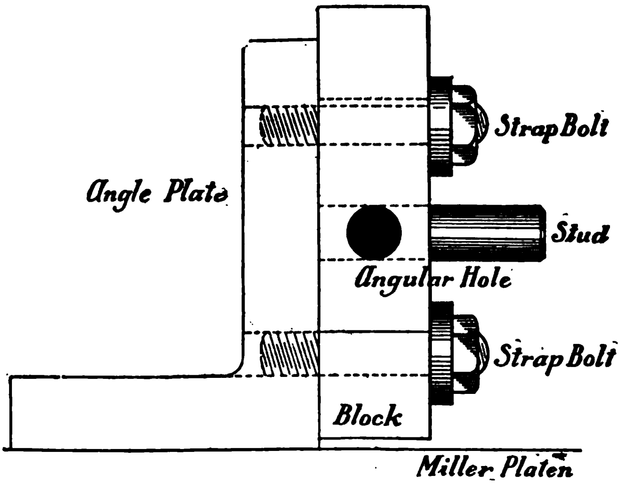


FIG. 305.

If you are machinist, tool-maker, or die-maker, learn of the multiple uses of the micrometer-caliper and the height-gauge; and your ability to do fine and accurate work will be further developed and your earning capacity will be increased. If you are a shop manager, superintendent, or foreman, furnish your departments and tool-rooms with such tools and teach your men how to use them; as by so doing your shop will produce more and better work accurately with ease.

CHAPTER XX.

Mould Construction.

MOULDS.

As not infrequently the making of moulds form part of the tool-maker's work it will be well to devote a chapter in this book to this interesting branch of his art.

Moulds are used to-day for the production of a variety of articles too numerous to mention. Rubber goods, soft metal ware, composition goods, glassware, china, and a thousand and one other things that form an integral part of our twentieth century civilization, are produced in moulds made by our most skilled tool-makers. Let no one think that moulds require but little skill to construct; for if they do they will find themselves greatly mistaken. In order to construct moulds successfully the mechanic must be skillful and accurate. In order that the articles produced in them shall be as desired, and exact duplicates of each other, the moulds must be of the most accurate construction. In fact an accurate mould must be constructed in much the same manner as an accurate drilling-jig would be, as its products are usually of the interchangeable class.

In order that the tool-maker may be assisted in deciding upon the proper type of mould to adopt for the production of an article of a given shape, size, and form from a given material, I shall illustrate and describe in the following pages a number of sets of moulds of the most approved construction. The descriptions will also point out the way to construct them properly.

MOULDS FOR PENCIL CRAYONS.

Fig. 306 shows a face view of a mould for pencil crayons. As will be seen, it was made in two parts and produced twelve crayons at once. Two castings *A* and *B*, 6 inches wide by 7 inches long, with lugs on one end of each for the hinge portions, were planed all over, with care to get as smooth and true surface as possible. The castings were very close-grained and totally free from blow-holes. After they were planed they were scraped on the sides on which the moulds were to be, until they were as near true as it was possible to get them. The lugs of the hinges were then machined so that *A* fitted within *B* snugly. The halves were then clamped together and the holes drilled and reamed through the lugs for the pins *D*, which were driven in. The plates *A* and *B* were then held in the vise and milled through one side, leaving a rib on the side of each, as shown at *C C*, and a depression *R* between them. While they were still clamped together the centres for the twelve moulds were laid out and prickpunched.

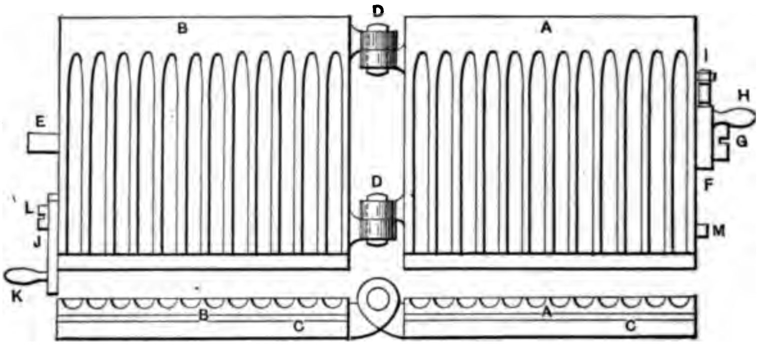


FIG. 306.

Next the pins *D D* were removed and the plates separated. We now have a centre mark on the face of each plate for each of the twelve moulds. The plate *A* was then strapped on the table of the miller, dead square, and a line was struck from each centre across the plate. A convex cutter, of $\frac{1}{16}$-inch radius, was then used, and, starting at the mark, was run along the line on the face to within ¼-inch of what was to be the total depth of the mould. This was done on all of the twelve centres, and the other plate was milled likewise, so that when the pins *D D* were

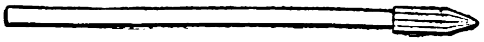


FIG. 307.—The Reamer.

inserted and the plates closed and clamped together there were twelve holes, $\frac{1}{8}$-inch in diameter, straight through the centre of them, or a half of a $\frac{1}{8}$-inch circle in each plate.

The plates were then stood with the side *c c* up, and a drill $\frac{1}{64}$ of an inch under the final size, and extra long, was run down through each of the $\frac{1}{8}$-inch holes to within $\frac{3}{8}$-inch of the bottom, the $\frac{1}{8}$-inch hole in each keeping the drill perfectly central. A special reamer, of the shape shown in Fig. 307, was then made and fed down into the hole left by the drill, and by feeding down very slowly a smooth round hole was made with the shape of the point in the bottom. All the twelve holes were gone over several times, until the exact depth was reached in each. The mould was then opened, and all the dirt and chips were cleaned out. It was then closed and reclamped. Several pieces of $\frac{3}{16}$-inch drill-rod which had been roughed all over were inserted —one in each of several holes—and melted lead poured around them. When they were cold the mould was opened and the lead forms were withdrawn, thereby furnishing several good laps. The laps were run at a high speed in the drill-press, using a generous amount of oil and emery, and the holes, or moulds, were lapped and polished to a nice, smooth finish. The plates were then opened, and after being well cleaned with benzine there were seen twelve perfect semicircular grooves of the size required in each plate, with dead-sharp edges that would leave no fins on the work. The pins *D D* were then eased a little, so that the mould could be opened without difficulty.

The next thing to be done was to make the latch *F*, shown in Fig. 308. This was made of $\frac{1}{4}$-inch flat steel and fastened to

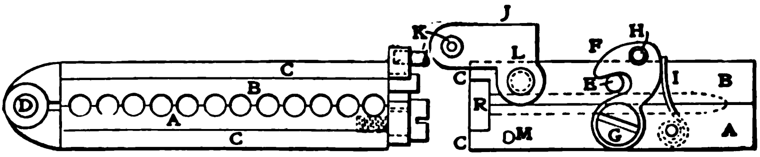


FIG. 308.

the plate *A* by a shoulder-screw. A small stud was let into *F*, for a handle *H*. The spring *Q*, of stiff spring steel, was made and fastened so as to keep a strong tension on the latch *F*. The lock-pin *E* was then made and hardened and inserted in the plate *B* so that, in order to hold the two halves of the mould fast and snug, the half *B* was brought down sharply on to *A*, and the pin *E* striking the latch *F* it was forced back until it snapped over the pin, thereby locking it. This proved a simple and reliable latch and was quick to manipulate. The swinging plate *J* for closing the channel *R* was then made of flat, cold-rolled steel and worked out and finished to the shape shown, with a small handle at *K* and swinging on the screw *L*. The stop-pin *M* was let into *A* and filed off so that the plate would swing over and rest on it, thereby closing the channel and preventing the liquid material from running out. The other end was closed likewise, and the mould was then complete. It produced nice, smooth crayons without the trace of a fin or a lump on the entire surface. A slight shrinkage which resulted in them after they became hard, allowed of their easy removal from the moulds.

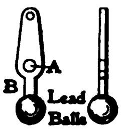


FIG. 309.

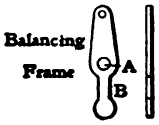


FIG. 310.

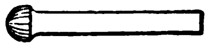


FIG. 311.—Butt Mill.

MOULDS FOR LEAD BALLS.

In Figs. 312, 313, and 314 is shown a mould for casting a lead ball on to a sheet-brass frame, as shown at Fig. 309. This device was used as part of a balancing mechanism, and it was necessary to have the balls all exactly the same weight and size, and in the same position on the frame. The mould used is shown in three views. Fig. 312 shows an inside view of each of the two sides; Fig. 313 shows the bottom, and Fig. 314 the top. The two halves of the mould were castings, and were machined all over to the same size, with one dead-smooth side. After being scraped in order to true them, one of them was held in the milling-vise, taking care to have the vise true and the work down solid. Then the butt-mill shown in Fig. 311 was held in the small chuck and the table moved until the mill, while running, just touched the end of the casting at *C*; the table was then moved outward and along a certain number of thousandths of an inch (and a memorandum made of it) for the first hole of the mould. Care had been taken to finish the butt-mill to a perfect half-circle of the radius required. The work was then fed against it and the mill let in the required number of thousandths, or to the depth of exactly half the diameter of the mill. The screw-dial graduation was then noted, and the work brought back and moved along for the next hole, and so on until the twenty-one halves were finished.

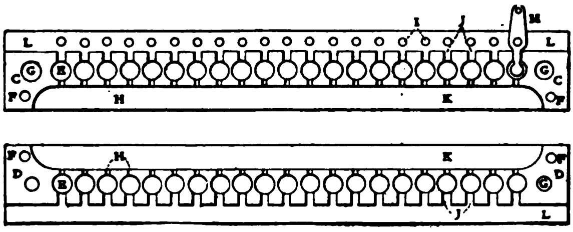


FIG. 312.

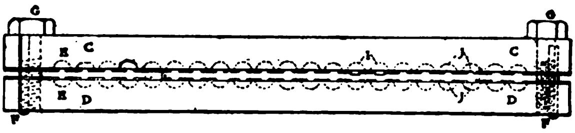


FIG. 313.

The other side *D* was then held in the same manner, the mill set and fed in the same number of thousandths as before and then each one milled to the same depth as the others. After this was done the halves were removed, and two brass balls were turned up and finished to exactly the same diameter as the moulds, and one inserted in the last hole in each end of the plate *C*. The other plate *D* was then placed on the top, thereby locating the half-moulds perfectly true with each other. A hole was then drilled at each end and reamed for the dowel-pins *F F* which were made and driven into *C*. The holes in *D* were eased so

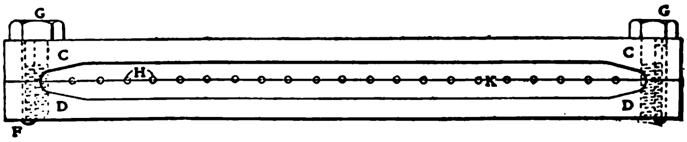


FIG. 314.

that D would go on the pins nicely. This proved a simple way of locating the molds exactly true with each other. The holes for the cap-screws G G were then drilled and the two sides C D held fast together. A cutter just the thickness of the stock used for the frames was then run straight through at L where the two pieces C D lay together, to the depth shown. C and D were then separated, and the centres laid out for the holes opposite each mould, as shown at I I. The holes were then drilled about $\frac{1}{4}$-inch deep, and reamed to allow the pins to be driven in to hold the frames in place, as shown in the upper right-hand mould. Each of the sides was then set up in the shaper and a tool just the width of the frame at B centred with the holes I I opposite each mould, and a channel planed into the centre of each mould, as shown at J, to the same depth as L. The idea and form are shown clearly in Fig. 312. The parts C and C were then put together and the screw G tightened and the holes drilled through which the lead was to run into the moulds, as shown at H, using a No. 40 drill and running into the centre of each mould, leaving half a hole in each. The sides C and D—still together—were then held in the miller-vise, and an angular cutter was used to mill a trough for the metal at K to the length and width shown, and, for depth, to within $\frac{3}{32}$-inch of the moulds, leaving the small channels as shown. The two sides were then separated and the faces polished with fine emery-cloth and all the burrs removed, being careful to leave the edges of the moulds sharp. The small pins were made and driven in to the holes I and then filed down to just the thickness of the frames, and the tops slightly rounded. A frame was then entered on to each of the pins, as shown at M, thereby holding them all central, the channels J keeping them steady. The two sides were then put together, and the mould being complete, it was held in the vise. The lead was heated to run freely, poured into the trough K and running through the small holes H into the mould. After the metal had set, the screws were loosened, D lifted off, the casting removed, and the balls chipped off at the small neck caused by the holes H, leaving twenty-one balancing frames with a perfect half at the end of each, all exactly the same. The one thing necessary in making a mould of this kind is a perfect mill and accurate spacing, and the work resulting will show no fin. The machine used was a Cincinnati universal, and it was surprising how dead accurate the spacing was, there not being a difference in any of the work produced, either in size or shape.

MAKING MOULDS FOR TELEPHONE-RECEIVER PIECES.

The moulds here shown in Figs. 315, 316, and 317 are of a type used in manufacturing imitation rubber or composition goods for various purposes, such as syringes, bicycle handles and parts of the telephone. The moulds were used for moulding the receiver case from a composition which, when hard, closely resembles rubber, and is known as electrose. Moulds of this construction are used in the hydraulic press, and the composition is

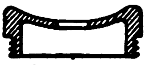


FIG. 318.—The Piece to be Made.

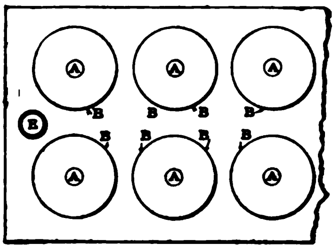


FIG. 315.

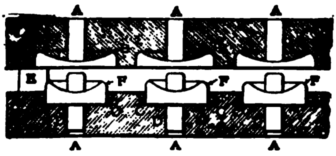


FIG. 316.

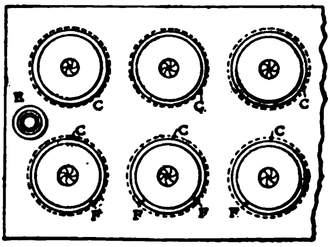


FIG. 317.

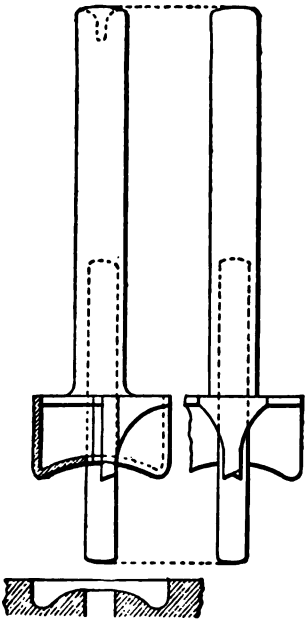


FIG. 319.

in a liquid form when pressed into the mould. The article produced is shown in a cross-section in Fig. 318. The top or face is concave and the edges are rounded. The case is thin at the centre and heavier at the outside, terminating in a square shoulder and a thread of 18-pitch. There is a ⅜-inch hole through the centre.

For the mould, pieces of flat soft steel were planed, clamped with the smooth sides together, and a hole *E* at each end drilled and reamed for dowel-pins. The pins were forced tightly into the lower plate and projecting properly into the upper plate.

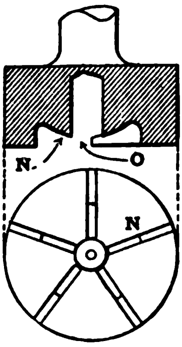


FIG. 320.

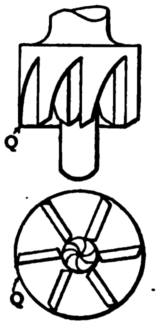


FIG. 321.

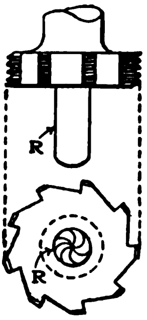


FIG. 322.

The sides and ends of the plates were then squared together in the miller, and the twelve holes *A* were drilled through both sections and reamed to finish size. A pair of templets of the inside and outside shape of the article were filed out and then special counterbores, finishing-tools, and the tap were made. The first tool, Fig. 319, was for the too of the case in the upper section, and, Fig. 320, was for the face of the core *F* in the lower section. *N* is the forming- and cutting-edge and the hole *O* fits the stem of the core. The straight face counterbore *Q*, Fig. 321, finishes the twelve moulds in the lower plates, leaving them square at the bottom and sizing them for the tap. This tap, Fig. 322, as well as the three counterbores, had a central or guide-pin fitting for the reamed holes.

The upper plate was clamped (not too tightly) to the drill-press table, with one of the holes *A* directly under the stem entered the hole *T*, as shown in the cross-section of the plate. The counterbore was then fed down into the plate to the proper depth, and all the twelve holes were finished in this manner, which completed the upper plate, except the lapping.

The first counterboring of the lower plate was accomplished in the same manner by the flat-faced counterbore, Fig. 321. The next operation was to tap the holes, which was done in the same drill-press, running very slowly and using plenty of soap-water as a help in cutting, and by careful work, and by running the tap in and out a few times, a sharp, smooth thread was secured. The numerous flutings of the tap, Fig. 322, worked admirably. There was also very little lead to the tap, as we wished the first thread in the finished case to be as full as possible.

The cores were then made of machine steel, first cut into lengths for two. These pieces were first turned at both ends to form the stems *D* to be driven tightly into the hole *A*. The pieces were then cut in two and held by the stem in a nose-chuck that ran perfectly true, when the stud at the opposite end was finished to fit nicely in the holes *A* in the upper plate. After this was done to all of them, the facing- or forming-mill, Fig. 320, was used for the face of the cores. The cores being held by the stem *D* in the nose-chuck, the centre in the end of the shank of the facing-mill was placed on the tail-centre and the short stem, turned on the face of the core, entered the hole *O* in the facing-mill, which was then fed in until the shape and size desired was produced on the face of the core. The twelve cores were then highly polished and driven tightly into the hole *A* in the lower plate. All burrs thrown upon the face of the plate by the tools used were then removed, leaving a sharp edge to each of the moulds.

There then remained to finish the moulds the lapping and polishing of the upper plate which formed the faces or tops, and which required a high shining polish as they left the mould. We made a few lead laps by pouring lead into the sections *B*, casting them around steel stems, which in use projected into the holes *A*, and then, by using flour, emery, and oil and running the laps as fast as possible, the moulds were lapped to a finish and polish that was very nearly perfect. By putting the two plates together it was seen that there was not the slightest defect in the alignment of the holes *A* in both, testing them as we did with a standard plug-gauge. One side of each of the plates was then marked "Front" to avoid mistakes.

When moulding the cases, the upper plate was removed, and the composition was poured over the face of the lower plate. The upper plate was then replaced, and the projecting stems of the cores *F* in the lower plate entered the holes *A* in the upper plate, thereby preventing the liquid from squeezing out and also forming the hole *J* in the finished case. The two plates were then placed under the hydraulic press and sufficient pressure was brought down on them to press the fluid into every portion of the moulds, the pressure being so great as to force every bit of surplus composition from between the sections. This composition was used while very hot, and required a few seconds to cool before removing. When cooled, the upper section was removed, and the slight shrinkage resulting from the cooling allowed the finished cases to be removed by screwing them out of the lower plate by hand. When thus removed they had a fine, smooth polish on all the outer surfaces and a good, sharp, smooth thread.

HOW AN ACCURATE SET OF MOULDS WAS MACHINED IN THE PLANER.

In Fig. 323 are two views of the finished lower section of a mould used for moulding square sticks of crayons with one end curved and tapered, as shown in Fig. 324. There were ten sets of these moulds to be made, and as we were getting a good price for them we were glad to get the job. Now, as will at once be seen, the job is a milling job, and the universal milling-machine the machine to do it in. As we had no milling-machine, however (universal or otherwise), we had to look around for other means.

At last we decided that they could be finished throughout in the planer by the use of a few special tools and attachments. Fig. 325 shows how the sections of the moulds are cored out at the back at *A A*, leaving a rim all round the outside. These sections, or plates, were of cast-iron of very close grain. The twenty castings for the ten moulds were first planed on the top and bottom, and the mould face of each scraped, so that the sections would surface at all points. The sections were then paired and the holes *B B* drilled and reamed through them, in the positions shown, for the three dowel-pins of Stub steel. These pins were driven tightly into one section of each of the ten moulds, and the holes in the other sections eased up. The two sections of each mould were then numbered and the moulds, with the sections clamped together, were then strapped on the planer-bed and their four sides planed square with each other and with the mould faces of the section, care being taken to finish the lot of ten to the same width and length. We were now ready to finish the moulds proper, and to do this the tools and fixtures shown in the accompanying illustrations were made.

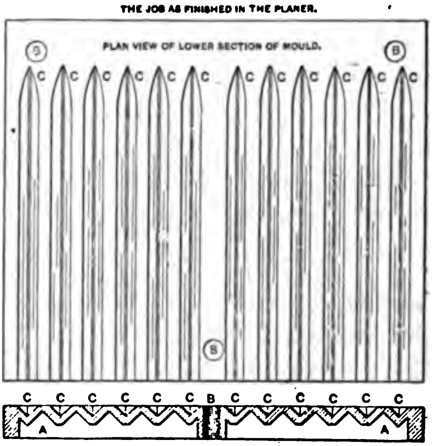

THE JOB AS FINISHED IN THE PLANER.
PLAN VIEW OF LOWER SECTION OF MOULD.
B
B
B
C C C C C C C C C C C C
C C C C C C B C C C C C C
A
A
CROSS SECTIONAL FRONT VIEW.

FIG. 323.

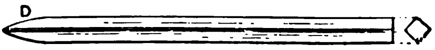


FIG. 324.—The Piece Produced in the Moulds.

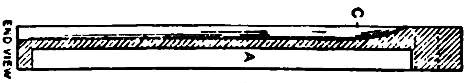


FIG. 325.

As seen in Fig. 324, the crayons produced in the mould were required to be $\frac{5}{16}$-inch square, with one end tapered and curved to a 1¼-inch radius. They were to be finished so that they would present a smooth surface on all sides, without fins and with the ends tapering symmetrically. To accomplish this result in the planer it was necessary to provide means for raising the forming-tool (for finishing the moulds) so as to produce the shape desired. The first thing made was a templet. This templet was worked out with one square side to work from and then finished to a 1¼-inch radius. It was used to finish the cam shown in two views in Fig. 326 and on the planer-bed in Fig. 327. This cam was of cast-iron with ears at each end to admit fastening-bolts, and with the cam faces long enough to take in the entire length of mould sections. It was first planed on the back and the tongue *G* fitted to the central slot in the planer-bed. The cam face *F F* was then planed up and finished to the templet, shown at left of Fig. 326, after making sure that it was at right angles with the sides of the tongue *G*. The front side of the casting was also squared so as to have a locating side for the mould sections to

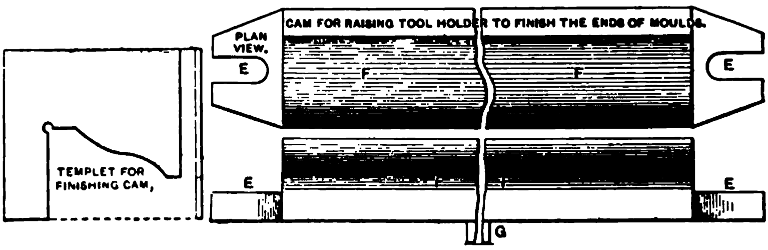

PLAN VIEW.
CAM FOR RAISING TOOL HOLDER TO FINISH THE ENDS OF MOULDS.
E
F
F
E
TEMPLET FOR FINISHING CAM,
E
E
G

FIG. 326.

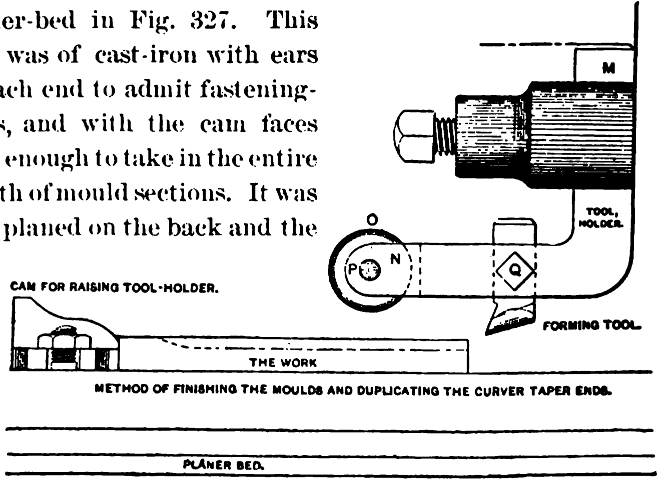

M
TOOL, HOLDER.
O
P
N
Q
FORMING TOOL.
CAM FOR RAISING TOOL-HOLDER.
THE WORK
METHOD OF FINISHING THE MOULDS AND DUPLICATING THE CURVED TAPER ENDS.
PLANER BED.

FIG. 327.

square against. Next came the tool-holder. This was got out of a bar of $1\frac{1}{8}$-inch square mild steel, bending and drawing down one end to $1\frac{3}{8}$ by $\frac{7}{8}$, to the shape shown in the front and side views of Figs. 327–330. The end of the extension at *N N* was milled through with a $\frac{3}{8}$-inch cutter to admit the roller *O* of machine steel, which was finished to fit the slot *N N* snugly, and to $1\frac{3}{8}$-inch in diameter, located by the $\frac{7}{16}$-inch stud *P* to revolve freely within the holder. A $\frac{3}{4}$-inch square hole was worked through the holder to admit the forming-tool, Fig. 331, care being taken to get it square with the sides of the roller *O*. A hole was also drilled and tapped to admit the set-screw *Q* for holding the forming-tool. This tool, Fig. 331, was of $\frac{3}{4}$-inch square tool steel, finished at *R* to a $\frac{5}{16}$-inch right angle, terminating in a square surface on each side at *S*. The correct shape of the cutting portion was carried back to the full thickness of the tool, giving the cutting-edge the amount of clearance shown. This completed the tools necessary to finish the moulds in themselves.

Now, as will be seen in Fig. 323, the moulds are constructed to produce twelve crayons, and it is necessary to space the twelve moulds *C* accurately, so that those in both sections will coincide with each other perfectly when the sections are fastened together. To do this, some kind of an indexing device was necessary. The use of the notched hand-wheel, Fig. 328, and the "flopper" or index-pawl, Fig. 329, answered for this, and allowed of the spacing of the moulds being acccomplished with rapidity and very little trouble. This hand-wheel was fitted to key on to the horizontal feed-screw of the planer and had a notch cut into its rim in the position shown. The "flopper" or index-pawl consists of

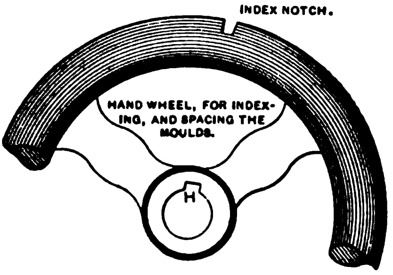


FIG. 328.

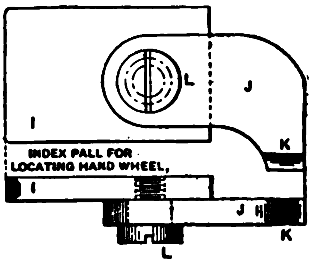


FIG. 329.

three parts: the back-plate *I*, the flopper or pawl *J*, finished at *K* to fit the notch in the hand-wheel, and the shoulder-screw *L*, for fastening the parts together. This completed all fixtures necessary to the finishing of the moulds.

The manner of finishing the sections in exact duplication of each other and spacing them correctly is shown in Fig. 327. This is sufficiently clear to be understood with a short description. The cam for raising the tool-holder is fastened to the planer by bolts at either end. The section of the mould marked "the work" is located squarely against the square front of the cam; lengthwise and sidewise against the stop. It is then clamped securely to the platen of the bed. The tool-holder is now fastened in the tool-post—the apron of which has first been set perfectly square with the planer-bed. The forming-tool is fastened within the holder—squaring it with the work by means of the parallel edges *S S* and allowing it to project out of the holder so the point of the cutting-edge is $\frac{7}{16}$-inch below the face of the roller, as in Fig. 327. The stroke of the planer-bed is then set, the hand-wheel fastened on the feed-screw, and the "flopper" clamped so that the end *K* will enter the notch in the hand-wheel, the back-plate of the "flopper" being clamped to the upright side of the planer.

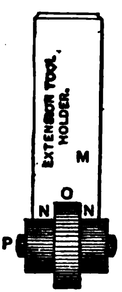


FIG. 330.

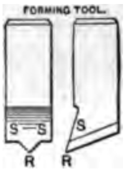


FIG. 331.

Everything is now ready: Starting from one side of the mould-plate, the forming-tool is moved over by revolving the hand-wheel a given number of times, and the indexing-pawl is dropped into the notch. The planer is then started and the forming-tool is gradually raised, thereby finishing and cutting the mould at this end in exact duplication of the shape of the cam face. To gauge the depth of the moulds the tool is fed down until the straight edge *S S* of the tool touches the face of the mould-plates. When the first mould is finished the tool is moved over the necessary distance by revolving the hand-wheel and indexing in the notch, and the operations are repeated until all twelve of the moulds in the section-plate are finished. The plate is then removed and another set up in the same manner and finished.

The twenty sections or mould-plates are all finished in this manner, each one being an exact duplicate of the other, and all coinciding perfectly when put together.

The method used here for finishing these moulds can be adapted for a large variety of different work, as will be at once seen, and the labor and expense incurred will not exceed that called into play if the work was done in the milling-machine.

MOULDS FOR BICYCLE HANDLE-TIPS.

In Figs. 332 and 333 are shown plan views of the top and bottom, respectively, of a set of moulds for the moulding of composition bicycle handle-tips, and in Fig. 336 a cross-section of the mould complete. The piece produced is shown in Fig. 335 and the drawn and perforated tin shell which forms the skeleton of the work, and around which the composition material is moulded, is shown in Fig. 334. The perforations in the shell or ferrule are to allow of the composition running into them when the tips are being moulded. The moulds shown produce fourteen tips at a time, and as the construction of them entails considerable practical knowledge and skill, it is of sufficient interest to describe.

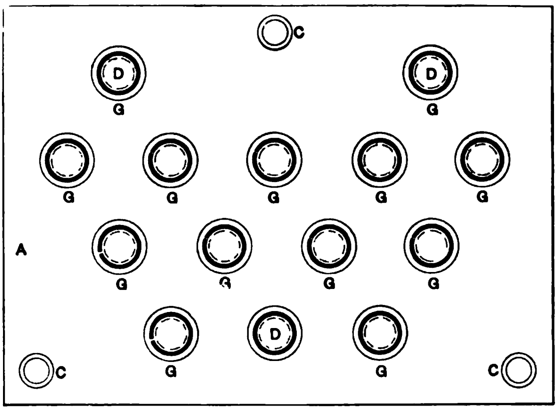


FIG. 332.

Two mild-steel plates for the two sections *A* and *B* of the moulds which form the top and bottom respectively, were first planed all over, and one side of each scraped until they surfaced

—when placed together—at all points. Both plates were then clamped together and holes drilled and reamed through both for the three taper dowel-pins *C C C*. The pins were then got out and driven into the bottom plate, and the two sections placed together, and a cut taken off all four sides to get both plates duplicates of each other. The top section was then removed from the other and the face laid out for the fourteen cores *C* in the relative positions shown in the plan views. Holes were then drilled through the plate at these points and reamed to size ($\frac{7}{16}$-inch), and then countersunk slightly at the back. The two sections were then reclamped together, the three dowels *C C C* locating them—and the holes in the top section transferred to the lower, drilling into a depth slightly less than the total depth to which the moulds were to be finished, as shown at *E* in the cross-sectional views, Fig. 336. The upper section was now removed and the holes drilled in the lower section counterbored to $\frac{1}{4}$-inch in depth, and in diameter to the size of the reamer, Fig. 337. The semicircular channels in the face of each mould at *F* were then

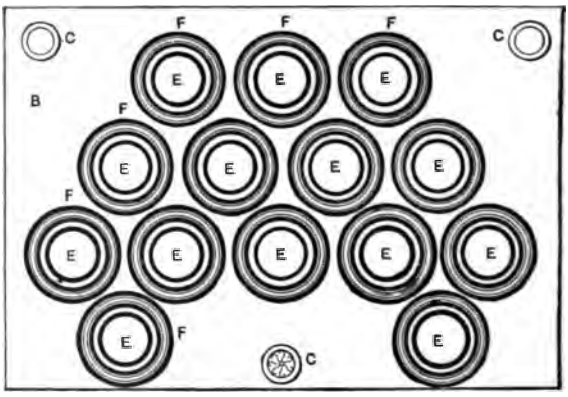


FIG. 333.

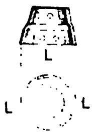


FIG. 334.

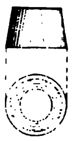


FIG. 335.

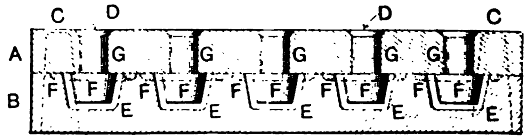


FIG. 336.

let in, and finished by using the tool shown in Fig. 338, the end of which, at *H*, fitted the holes reamed by the reamer, Fig. 337, snugly, the cutter *J* finishing the channels to the required depth. A finishing, reamer of the exact taper and size required was then let in, finishing the moulds to the shape and depth shown in Fig. 336, the upper edges or largest diameter of each just meeting the inner edges of the semicircular channel *F*, leaving a sharp edge all around. The moulds were then lapped to a high finish, getting all marks and scratches out by the use of the copper expansion lap shown in Fig. 339, and flour, emery, and oil. The lower section of the moulds was now complete. To finish the upper section there remained the fourteen cores, as shown in the plan view, Fig. 332, and in the cross-sectional views, Fig. 336, at *G*. These cores were made in the lathe, and were of machine steel, first cutting off pieces of sufficient length to get out two cores, and then centring them and turning down each end to fit tightly the reamed holes in the upper-section plate. The pieces were then cut in two and held in a nose-chuck by the finished stems, and the core faces turned and finished to the required shape and size with a forming-tool—that is, to just fit the inside of the tin ferrules, Fig. 335. The stems of these cores were then driven into the holes in the upper sections, shouldering tightly within the plate as shown at *D*. The mould was now complete and ready for work.

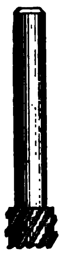


FIG. 337.

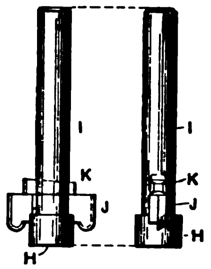


FIG. 338.

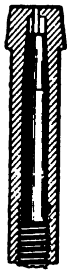


FIG. 339.

One of the perforated tin ferrules, Fig. 335, was slipped on to each of the cores and the composition to be moulded spread into the moulds *E*. The two sections were then located together by the three dowels *C C C*, and the mould placed under the hydraulic press and the two sections forced together, which caused the composition to compress to the limit, with the surplus forced out from each mould and into the semicircular channels in the face of the sharp edges on the insides, trimming the stuff from that within the moulds. The mould was now removed from the press and the sections separated, when, by rapping the lower section and the back with a mallet, the moulded pieces dropped out, the result being fourteen highly finished tips of the shape shown in Fig. 344. The perforated tin ferrules on the inside of the tips made them strong and durable, and the presence of the pierced holes *L* around the shells for the composition to run into, eliminated the possibility of the two parts separating, or the composition loosening or chipping off.

MOULDS FOR "POKER-CHIPS."

In Fig. 340 is shown a cross-section view of a mould for poker-chips, and in Fig. 341 a plan view of the bottom section. As both sections of this mould are exact duplicates of each other, the one illustration will serve for both. The manner of

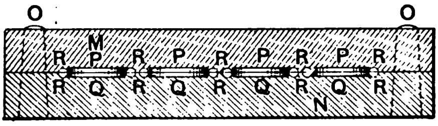


FIG. 340.

preparing the mild-steel plates for the sections *M* and *N*, Fig. 340, and the manner of locating them by the three dowel-pins *O O O* are the same as that pursued in the other. As can be seen in the plan view of the section-plate, Fig. 341, the mould had a capacity of sixteen chips. The manner of spacing these moulds and finishing to coincide with each other is as follows: The two plates after being doweled together are planed square on all sides; one side of each then marked to work from, choosing opposite sides. One of the sections is then clamped facing the spindle to an angle-plate on the universal milling-machine, with the marked end resting squarely on the miller-table. The forming-mill, Fig. 342, is then held in the miller-chuck, and the table raised until the work is in line with the first row of moulds. The table is then moved along until the cutter will just touch the side of the plate. We now move the table longitudinally the exact distance required—by noting the graduated dial on the feed-screw—and the first mould is finished by moving the work against the cutter; letting it in the number of thousands required. The work is then backed out and the table moved for the next mould, treating each mould of the first line in the same manner and getting them exactly the same number of thousands apart. When the first row is finished, the table is raised the same distance as the space between the first row of holes, then, by starting from the same side for the first row, the second row of holes is finished, and so on until all are complete. The one thing necessary is the accurate spacing and sinking of the moulds, being sure to take up all back lash in the feed-screws before starting the divisions. When letting in the forming-cutter, a generous supply of oil was kept running on the cutter,

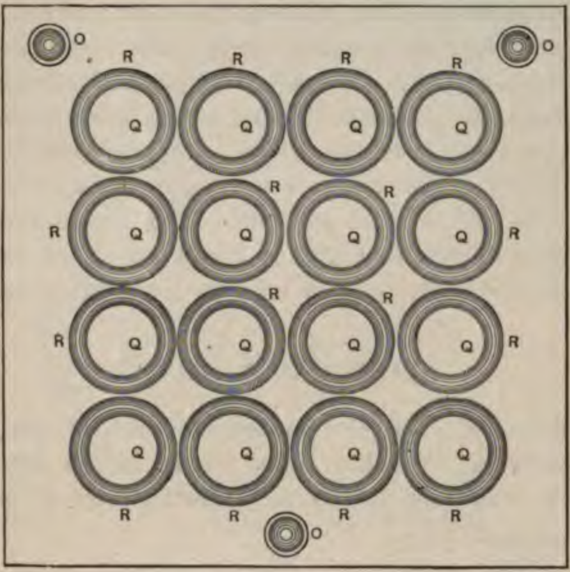


FIG. 341.

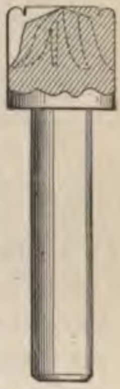


FIG. 342.

the cutting-edges of which had been ground and oil-stoned to take smooth polishing cuts.

The finishing of the other sections was accomplished in the same manner as the first, starting from the marked side and working from it as in the other. In the plan view, Fig. 341, *Q Q* are the moulds and *R R* the semicircular channels for the surplus stock to run into. These moulds were required to be finished so that the outer edges of the "chips" produced would be about 0.005 higher than the centres, this being necessary in order for the chips to "stack" well and even. The moulds were lapped and polished smooth by means of a lead-lap in the drill-press, running it at a high speed in order to get a high finish in the moulds.

SPHERICAL MOULDS.

Moulds and dies for spherical forms of various radii, such as globes and rings, often have to be formed in the lathe. Such moulds are used particularly in rubber factories for balls and

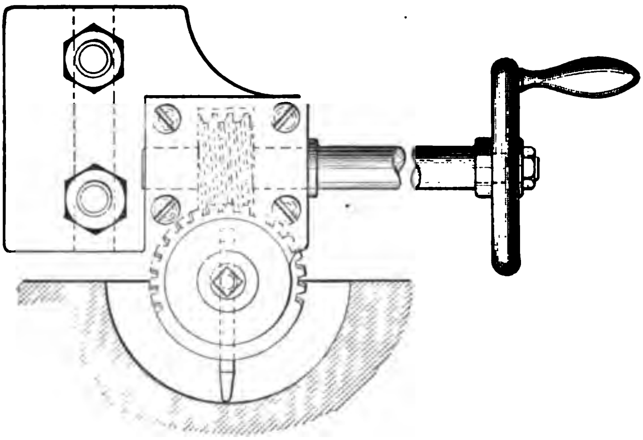


FIG. 343.

bicycle tires, and the little tool illustrated in Figs. 343 and 344 was designed for such requirements, as it was found rather expensive to make forming-tools for each size of mould that had to be made. The fixture was designed to be bolted on to the carriage of the lathe by bolts in the T-slot of the tool-carrying block, thus giving it all the ordinary movements given to a lathe-tool, with the additional circular ones.

The tool, as shown in the drawing, consists of the cast-iron base, having a tongue which fits the T-slot of the tool-block, and is firmly held thereon by the bolts shown. A cap is fastened to the base by counterbored screws, while projections upon it and a groove in the base serve to locate the cap. The worm-gear, having trunnions integral with it, is journaled in the extension or wings of the base and cap. Meshing with the worm-gear is the worm, the shaft of which is journaled by the base and cap and extends toward the front of the lathe, where it terminates in the hand-wheel at a convenient length. An oblong slot is cut in the worm-gear to receive the turning-tool, which is fastened by the central set-screw.

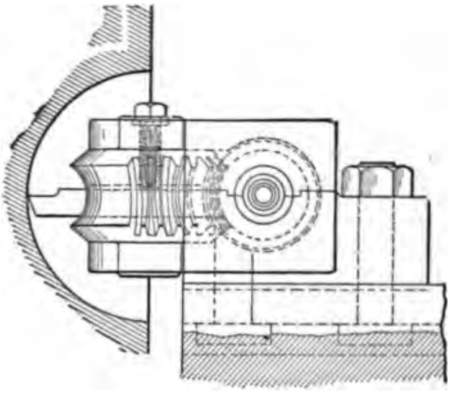


FIG. 344.

As moulds and dies are usually made in halves, it is not often required to turn out more than this, but proper proportioning of the fixture allows as much as two-thirds of the sphere to be turned out. The device, of course, will turn out moulds for circular rings as well as for balls by simply setting it out from the line of centres to the required radius.

CHAPTER XXI.

Special Tools, Fixtures, Devices, Arrangements, Contrivances, and Novel Methods for Metal-Working.

THE DEVISING AND CONSTRUCTING OF SPECIAL TOOLS.

WHILE the constructing of the regular types and standard classes of tools necessitates skill, accuracy, judgment, and experience on the part of the tool-maker, it is in the devising of special means for the rapid and economical production of special work that his ingenuity is utilized. The ability to devise special tools for special work is one to be prized, and should always be encouraged and developed. In this chapter are illustrations and descriptions of a large variety of special tools, fixtures, devices, arrangements, and novel methods for metal-working; by making himself familiar with them the mechanic will find no difficulty in devising means for the rapid production of any special part; while the descriptions of the proper ways to make them will show how to avoid all unnecessary expense and labor.

A SET OF TOOLS FOR MACHINING A CAM.

The illustrations show a set of tools for machining a repetition casting of unusual shape, which was used as a cam on an automatic machine for making fruit-baskets, and, as some of the tools are of a novel and improved design, a slight description of them will suggest their use for other work.

The casting machined is shown in Fig. 345. It is, to say the least, a rather difficult piece to machine, because of the irregular cam surface. This cam surface was required to be finished very accurately and so that the castings, when finished, would interchange perfectly. The other portions of the casting to be machined so as to interchange were the boring and reaming of the hole *A*, the facing of the hub at *G*, of the sides *C*, and the finishing of the conical surface at *D*. The hub *B* was left rough.

The number of operations required to finish the casting was three—the first being done in the turret-lathe and the other two in the engine-lathe. The first operation consisted of boring the hole *A* and reaming it, facing the hub *G*, and machining and finishing the conical surface *D*. The tools used in this operation are shown in Figs. 346 to 350. Fig. 346 is a combination boring and hub-facing tool used to bore the hole *A* and face the hub *G* at the same time. It consists of a long stem *H*, with the cutter *I* in a slot in the end held by the taper-pin *J*, and the hub-facing tool-holder *K*, which is located on the bar by the set-screw *L*, the point of which screws into a milled channel in the cutter-bar, as shown at *Q*. The hub-facing cutter *N* is held in position

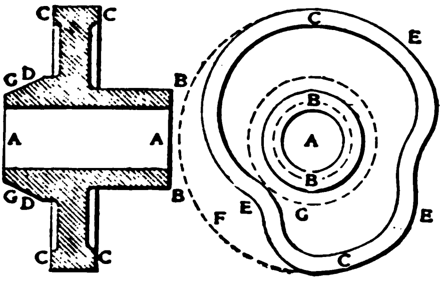


Fig. 345.

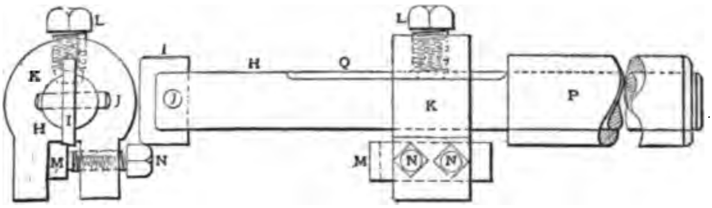


Fig. 346.

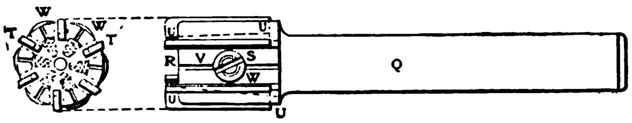


Fig. 347.

by the two set-screws *N N*. *P* is the usual split bushing as used in the turret-lathe.

For reaming the hole *A* the reamer Fig. 357 is used. This reamer consists of the body *Q*, of tool steel, and six cutters or blades *T*. These blades are let into inclined channels, as shown by the dotted lines at *U U*, to allow the readjustment after being worn, or after grinding. The blades are held by taper-headed screws *W* which are let into the centres of the narrow-sawed slots *V*. By tightening these screws the metal is forced tightly against the blades, thus holding them securely.

Fig. 348 shows the tool used for roughing off the conical surface *S*. The tool has three cutting-points *K* and is gradually slid along under the surface by the hand-lever, the shank of the tool being held in the tool-post. This surface was finished by a flat-bladed tool of sufficient width to take the entire line at once.

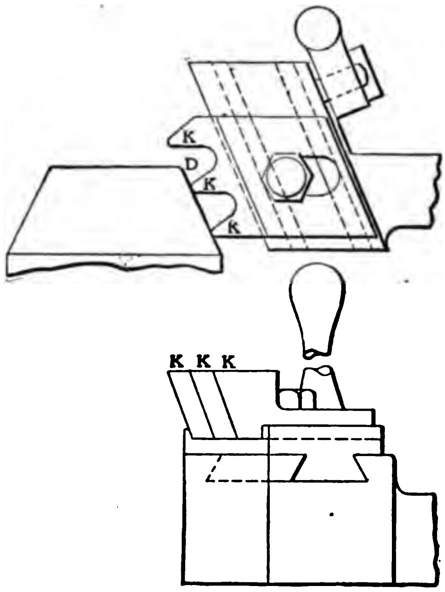


FIG. 348.

The second operation, facing the two sides *C C*, thus sizing the width of the cam face, is done in the lathe by the special double-facing tool, Fig. 349. Three castings are located on an arbor at once and fastened by a nut. The tool is held in the tool-post in the usual way.

The last operation, machining the cam surface, was the most difficult. It also was done in the lathe with four special fixtures. These were: A special slide-rest for the cutting-tool, a special cross-slide for the lathe, a combined master-cam and chuck, and a locating- and supporting-stud for the work. These fixtures, in position on the lathe with the work, are shown in Figs. 350 and

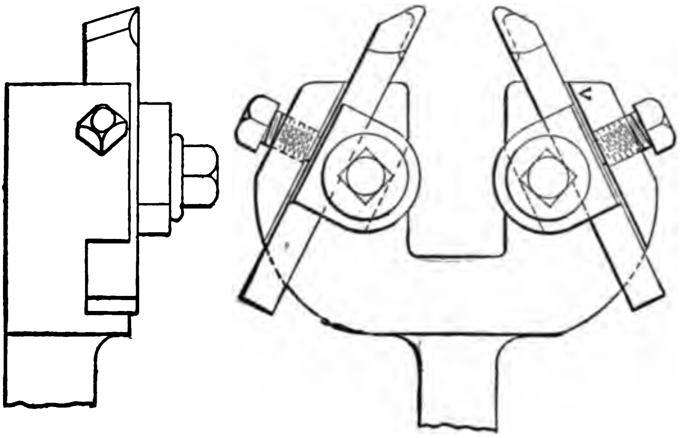


FIG. 349.

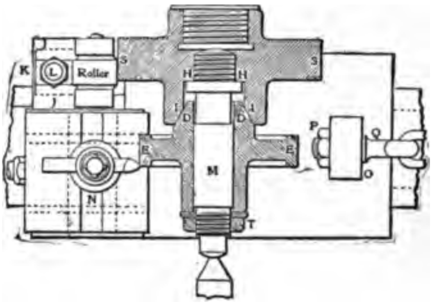


FIG. 350.

351. The master-cam and chuck was a forging, which was first fitted to the spindle of the lathe, after which the chuck portion was finished with an internal conical surface at *I I* as a locating-point for the conical surface *D D* of the work. The cam portion was then laid out and finished on the universal milling-machine.

The stud or arbor for the work was of tool steel finished as shown, hardened and screwed tightly into the chuck portion of the master-cam, shouldering on it at *H H* as shown; the surface *M* was then ground to fit the work.

The special cross-slide for the lathe is in reality a compound rest, the only difference being that the smaller rest does not swivel. The cam-roller was of tool steel and was hardened and ground to a smooth finish and located on a hardened and ground pin *G* within the bracket *K*. A chain *R* is attached to the hook at the back of the slide and is supported by a roller at the back of the lathe, with a heavy weight fastened to the hanging end of it. Thus the movement of the cross-slide is derived from the master-cam *S S* working against the cam-roller. As can be seen, the construction of the cross-slide is strong and the rigidity of the cutting-tool is insured. The cam surface was first turned to within a few thousandths of an inch of the finish size and then finished to gauge by grinding—this being easily accomplished by the use of a small tool-post grinder driven by a round belt from a drum overhead.

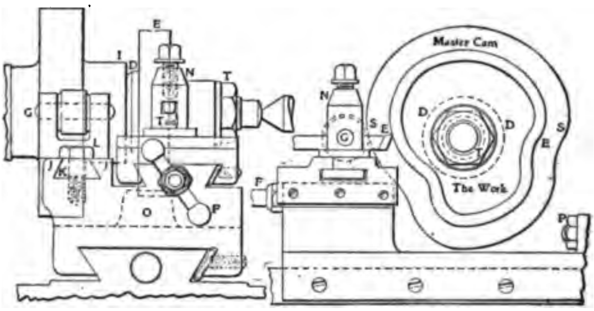


FIG. 351.

CUTTING A COARSE-PITCH SCREW.

Fig. 352 is a sketch of a coarse-pitch screw which, because of the unusual pitch, was cut and finished under difficulties. The screw was 30 inches long, 2 inches in diameter, with one thread to 3 inches. After rigging up the gears on the strongest lathe in the place it was found that the slowest speed we could get was too fast, and after breaking all the teeth a new pair of gears was got out to replace the broken ones. A piece of machine steel was turned up and reduced at one end to screw into the tapped hole for the gear-screw in the end of the lead-screw of the lathe, and an 8-inch pulley keyed on this extension piece. A spare countershaft was now located and fastened to the floor. The driving-belt was removed from the lathe and we then belted from the main shaft to the countershaft on the floor and from the countershaft to the pulley of the lead-screw. We thus reversed matters, and instead of the lathe-spindle driving the lead-screw, we had the lead-screw drive the spindle. Thus while the lead-screw fed the thread-tool at the proper speed the work turned very slowly and the screw shown and several others, as well, were finished without any further trouble.

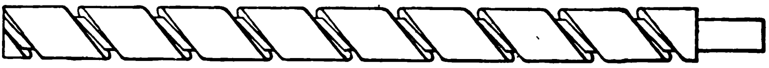


FIG. 352.

MAKING THIN THREADED BRASS RINGS.

In Figs. 353 and 354 respectively are shown the means used for accomplishing a nasty little job in a very simple manner. We were making a lot of thirty-two acetylene-gas lamps, and during the process of manufacture it was necessary to make and sweat a threaded brass ring into one of the shells. These brass rings were made from 2-inch brass tubing and were required to be finished to ½-inch wide and threaded 22-pitch. The tubing had a wall of only $\frac{1}{16}$-inch, and as it was impossible to cut off and thread the rings in the usual manner in the lathe, the following simple means were used: A piece of soft wood was turned up on centres to fit a length of tubing, as shown in Fig. 353—finishing one end somewhat smaller than the other, so that the tubing could be forced on. Then by driving this wooden arbor between the centres, the rings were cut off with ease, as shown, without in the least affecting their trueness. After being cut apart the rings would come off the arbor easily. The burrs were then removed with a hand-tool, and the rings were threaded by holding and locating them in a wood-chuck of the shape shown in Fig. 354. This chuck was of soft wood and was turned at *G* so as to allow of its being held in the regular lathe-chuck; then bored out on the face, so that a brass ring would fit tightly within it and true itself against the shoulder at *H H*. Four round-head screws at *J J J*, when tightened down against the edge of the ring, also helped to hold it. The rings were threaded in this manner by the usual threading-tool and fitted to a plug, and were removed from the chuck by screwing the plug in for a few threads and pulling the ring out. Some of the rings would not fit the chuck tightly, but by taking a piece of wet waste and wetting the locating portion of the chuck, it would shrink sufficiently to hold. Any one who has ever tried work of this kind with the usual means at hand in the lathe, will appreciate this simple and effective method.

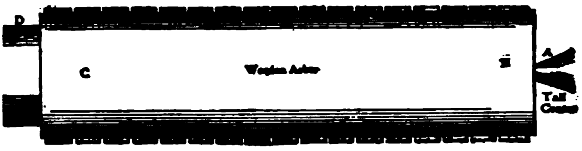


FIG. 353.

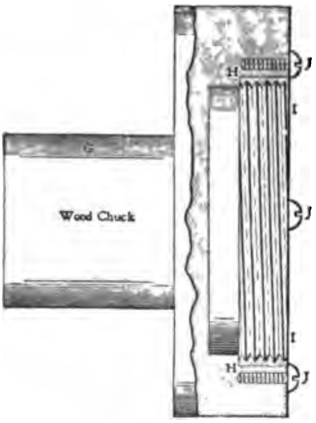


FIG. 354.

A DRILL-PRESS JOB.

The sketch, Fig. 355, shows how an unusual job was accomplished in a simple manner with the best means available, which were—to say the least—not meant for the job. The work was a base casting of a two-cylinder pump model, and it was necessary to bore two 1¾-inch holes in it in the position shown. The lathe we had was too small to allow of swinging it on the face-plate, and the only drill-press in the shop (which was a private experimental shop) was an 8-inch sensitive drill. So by means of the adjustable cutting-tool shown we did the job on the small drill. First we drilled and reamed two small holes the required distance apart for the centres, as shown at *K*, as locating- and truing-points for the tit *M* of the tool *R* as shown. The tool was fastened in the chuck and the work located and clamped to the table and the holes finished as shown in the sketch. The tool used for this job can be used for a variety of others as well.

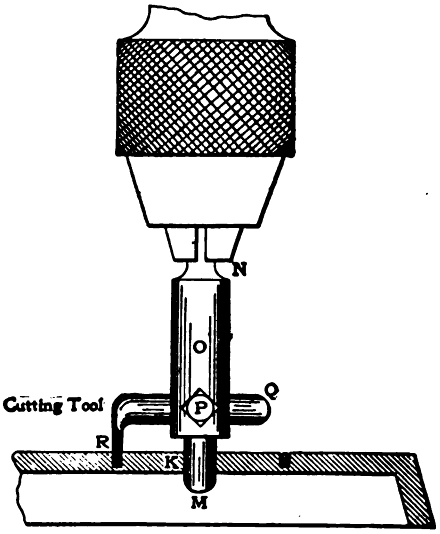


FIG. 355.

A "STEP-JIG."

The sketch, Fig. 356, is meant to show one end of a hard rubber plate which was accurately finished on the side to 7⅜ inches wide, 5½ feet long and to ⅜-inch thick. In this rubber plate there were to be drilled fifty-two rows of holes, ⅛-inch apart and 625 holes in each row, the size of a No. 60 drill. The number of holes in all was 32,500, and each and every one of these holes

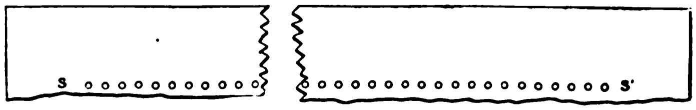


FIG. 356.

were required to be accurately spaced, as the rubber plate was to be used as a part of the mechanism of a music-box, a steel pin being afterward inserted into each hole. There was to be a ¼-inch margin on all four sides of the plate.

The jig used for drilling and spacing the holes is shown in two views in Fig. 357. As the sketch explains itself, very little description is required. As shown, there is one row of fifty-two holes running in a straight line from *J* to *J*, and ⅛-inch from the holes at the extreme ends of this line other holes as shown at *I I*. These two holes are for spacing the rows of holes in the plate when drilling, by drilling the first hole ½-inch from the end of the plate and then locating the jig for the next row by inserting the two locating-pins *K K* into and through the holes *I I* and into those coinciding in the plate. The holes in the jig were spaced and located in the universal milling-machine by using a small stiff centre-drill for centring all holes, and afterward drilling and reaming them on the sensitive drill. The manner in which the jig is used and the work drilled can be understood from the sketches. The drilling of these 32,500 holes took some time, and after each day's work on them it was necessary to lay the rubber plate on the planer-bed and put heavy weights on it so as to prevent it from warping during the night.

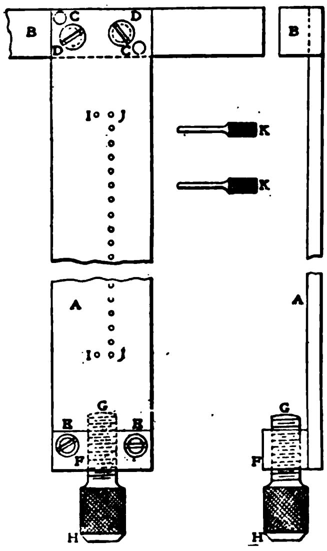


FIG. 357.

A DRILLING JOB IN THE PLANER.

I saw the following combination used to advantage one day while looking through a small country jobbing-shop. It consisted of a 1-inch drill, a lathe-centre, a dog, and a stick of wood about three feet long. They were used for drilling three 1-inch holes in the bed of an old planer. The lathe-centre was clamped in the tool-post of the planer and the dog fastened to the shank of the 1-inch drill. The point of the drill was entered into a centre-punch mark in the planer-bed, and the point of the centre entered into the shank end of the drill. With one hand the drill was turned by using the stick of wood as a lever, and with the other the tool-head was fed down. In this manner the holes were drilled. While the use of the lathe-centre and the cross-head as an "old man" was all right, I thought that the dog and stick method was rather obsolete, until the "boss" of the place told me that they had no ratchet.

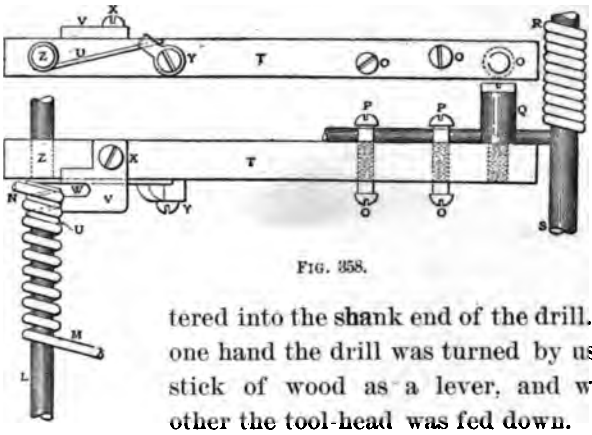


FIG. 358.

A SPRING-WINDING FIXTURE.

Fig 358 shows two views of a simple and handy little spring-winding fixture which, as the sketches show its construction clearly, requires little description. The body *T* is a piece of finished ½-inch square mild steel, and one end is constructed and fitted for winding gauged springs, while the other end is for closed springs. The end for the gauged springs has a hole through it at *Z* for the rod *L* on which the spring *M* is wound. For a gauge for winding the springs, the spring *U* is used, it being located and fastened to the sides of *T* by the small clamp *Y*. *V* is a small plate fastened to the body at *X*, with a guide-way at *W* for the wire. When in use the rod *L* on which the spring is to be wound and the end of wire are fastened in the lathe-chuck, the projecting end of the rod entering the hole *Z* in the winder. Then the winder is given a couple of turns around the rod, so that the gauger *U* will have twisted around the wire.

The fixture is then fastened in the lathe tool-post and the lathe started, holding the wire tight by the hand and letting it run down the guideway as shown.

The other end of the winder is used as shown. The screws *P P* and *O O* are for adjusting a guideway for the wire which passes under the roller *Q* and is wound around the rod *S*, as shown at *R*.

A SOLDERING FACE-PLATE.

One of the handiest things around the jobbing-shop is a soldering face-plate. The number of small, odd, and intricate little jobs which can be accomplished with ease by its use is surprising. The one we had was fitted up to locate and fasten on the face-plate of the Hendey-Norton lathe. It consisted of a disk of cast composition about one inch thick and slightly under the diameter of the face-plate. After being faced on one side it was located and fastened to the face-plate by means of four countersunk head-screws which were let in from the back, thus allowing of its easy removal when through with it. One of these plates should be kept in every tool-room, and one, 1 inch thick, will last a long time and pay for itself over and over again before being worn out.

MAKING COLLET SPRING CHUCKS.

The following kink I found very handy when making collet spring chucks of the shape shown in Fig. 359. After finishing them in the lathe, leaving, of course, enough stock to lap and grind to a finish, face them on an arbor and saw the spring slots as shown—that is, at the end of each slot, as shown at *T* and *V*, instead of cutting completely through at this point, leave a very thin wall of about $\frac{1}{8}$-inch long at the end of all the cuts. Then harden and temper the chuck as desired, and after lapping the inside to size, place on another arbor and grind the tapers as required. Then take a small, narrow broach and by entering it into the slots and hitting it a sharp blow with a hammer the thin

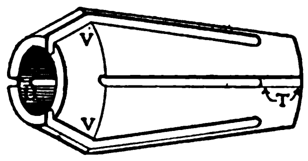


FIG. 359.

wall will break through. This kink I have used to the best advantage in shops which had no grinding facilities. When proceeding as aforesaid, it was possible to finish the outside and tapers to size before hardening without the possibility of the chucks running out to a noticeable extent. Of course in work of the utmost accuracy this method would not do. But then again, work of the utmost accuracy is not accomplished in shops where the tool facilities are not up to date.

A FLAKING-STICK.

In Fig. 360 is shown a sketch of a little kink which, while no doubt old to many, may be new to some. It is a flaking-stick, and may be used to produce that circular flaking often seen on the inside of watch-cases and often desired for a finish on different polished small parts. It consists of a stump of a lead-pencil and a piece of emery-cloth, as shown, fastening both in the chuck of the small drill-press, then running it fast and coming down on the work for a second and then shifting it and coming down again. The finished effect is fine when a little care is taken to move the work evenly.

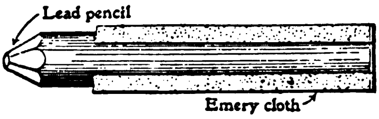


FIG. 360.

DRILLING HOLES IN A HELICAL SURFACE.

Fig. 361 shows a drilling fixture, with the work in position, for drilling a 500 lot of malleable iron castings of the shape shown. In these castings it was necessary to drill twelve equally spaced holes *c c c* around the helical portion. The design of the fixture and the manner in which it was used are shown clearly and can be understood without description.

MILLING IN THE DRILL-PRESS.

Fig. 362 shows the use of a small fixture for milling in the drill-press, a portion *J* out of a small eccentric cam-shaft *P*.

F is the fixture in which the work is located in the hole *G*. The work is located and prevented from turning while being machined by a portion of *P* resting in a turned depression in the top of the fixture at *H*. A hardened taper-pin *R*, with a flat face to bear against the work, secures it, as shown. *L* is the shank of the cutter-holder which is fitted to the drill-press spindle. The cutter *K* is keyed on and further secured by the nut and washer. The stem *M* of the cutter-holder runs in the hardened bushing *N* while the work is being machined.

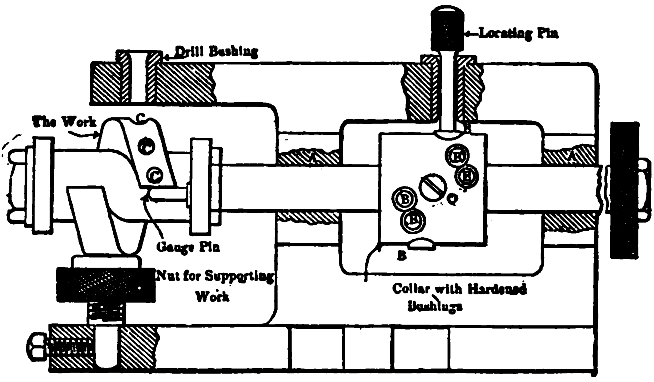


FIG. 361.

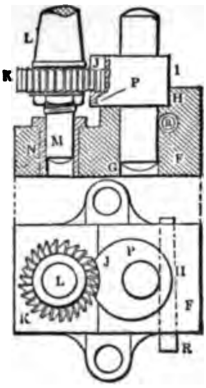


FIG. 362.

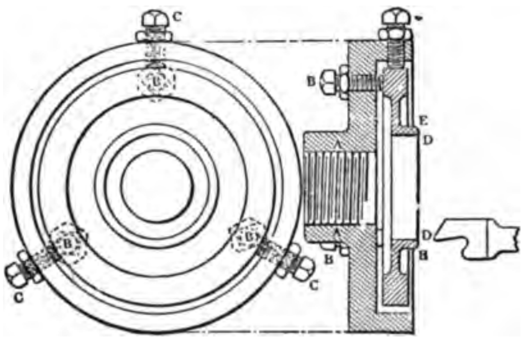


FIG. 363.

A SIMPLE LATHE-CHUCK.

In Fig. 363 are two views of a simple chuck used for locating and holding a cast-brass ring, while the inside at *D D* was being bored and the edge *E E* rounded by the tool at the right. There were a hundred of these rings to be done and the portions designated were the only points finished. The chuck proper was of cast-iron fitted at *A* to the lathe-spindle, and the face bored out for the work, as shown. The three set-screws *B* at the back were for locating the work true sidewise, while the three around the outside at *C* were for centre-truing and holding it. To fasten or release the work it was only necessary to tighten or loosen one of the screws *C*.

TRIMMING SHEET-BRASS BLANKS.

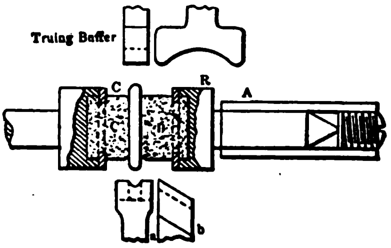


FIG. 364.

The arrangement shown in Fig. 364 was used for rounding the edges of sheet-brass blanks $\frac{3}{16}$-inch thick and $1\frac{3}{8}$ inches in diameter. There were 2,000 of these blanks and they were punched in a plain blanking-die. Finishing the blanks by the means available in a jobbing-shop was impossible, and for a while we thought that we were "up against it"; but one of the men, who had done considerable mould making in his time, told of a method which he had seen used with great success for finishing the edges of "poker-chips." This method was adopted, with the result that the job was accomplished with ease and at a very low cost. The piece *A* is fitted to a hole in turret of a small screw-machine, with a piece of hard spring rubber *B* attached to the projecting end of the press *R*. A duplicate of this piece *R* is held in the chuck on the spindle of the screw-machine. The rounding-tool is fastened in the front tool-post, while the turning-buffer is located in the back one. To machine a blank it is held by the fingers against *C*, while the piece *R* with the rubber front *B* is brought against it by moving the turret up and forcing the rubber against the blank, which is trued and sufficient pressure applied to hold it. The rounding off is then accomplished by the tool, and the blank, is released. The blanks were all finished to size in this manner without any trouble.

A DIE-MAKING KINK.

Fig. 365 shows a little kink which to the best of my knowledge is original. It consists of simply taking the upper half of a brass door-key and soldering it to the centre of a templet for a handle. When the templet is large, as is the one shown, the soldering of the key to it instead of a piece of wire is a great convenience. When the die is finished the key can be removed and laid away in one's drawer until required again.

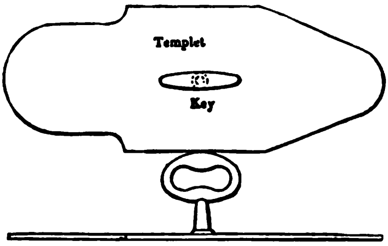


FIG. 365.

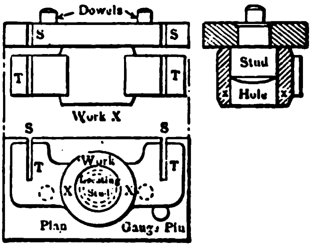


FIG. 366.

A SIMPLE SLOTTING FIXTURE.

Fig. 366 shows three views of a simple slotting fixture which was used to advantage for milling the slots *T T* in the casting shown. There were about 200 of these castings, and they were required to interchange. Before slotting they were bored and reamed at *X X* and the hubs were faced. The slotting fixture consists of a machine-steel plate into which the central locating-stud is riveted; and two dowel-pins are let into the back, as shown. These pins coincide with two holes drilled in the stationary jaw of the miller-vise. A gauge-pin in the front of the plate, at the right, serves to locate the work as required.

KEY-SEATING IN THE POWER-PRESS.

Fig. 367 shows the method used for cutting a keyway in the small cast-iron collar at *D*. These collars were used in a large number; for that reason the means shown were adopted for cutting the keyway. The broach is fastened in a holder, while the collar *A* is located beneath the stripper of the die-bolster. The stripper and locating depression are cut away at the front for facing and moving the work. The guide is of tool steel, hardened, and fits the circular portion of the broach snugly. The finishing of the keyways in the power-press by the means shown proved very satisfactory, far more so than by the old way of forcing the broach through under the arbor-press.

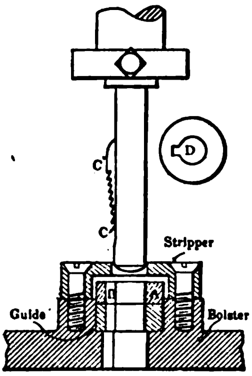


FIG. 367.

HAND CUT-OFF AND FORMING-TOOL.

The tool here shown in Fig. 368 was used for the rapid production of small work as sketched in *W*, Fig. 271, forming and cutting off at the same time. As a rule, all work of this kind is done in a turret-lathe or screw-machine. Pieces of the first shape shown in Fig. 373 were produced by the present simple device at the rate of 8,000 a day.

The tool was composed of two main parts, *A* the body, Fig. 269, and *B* the slide or tool-holder, Fig. 270. Having been planed on the various sides it was set up and dovetailed for *B* to an angle of eight degrees with the bottom. A hole was then bored and reamed at *E* for the bushing, and hole *D* tapped for the set-screw. A rib was cast up from the base and a hole drilled and tapped through its entire length at *C* for the adjustable stop-screw *H*. A hole was also cut through the bottom at *P* as clearance for the lower handle *T*. The slide or tool-holder *B* of cast-iron was then machined and fitted to the dovetail in *A* so as to run freely; a recess was also let in at *J* for locating the tool or cutter. A flat piece of machine steel, *D*, fastened by the two screws as shown, served as strap for holding the tool. A bushing of tool steel *E* was then finished to the size of the stock to be used and fitted tightly within *A*. This was cut away in front for clearance for the tool and left full in the back to steady the side. This was then hardened and slightly drawn. A stop-screw *H* was then made which consisted of a long threaded stem to fit the hole; the head was large enough in diameter to serve as an adjustable stop for regulating the length of the work. The forming and cutting-off tool C was made, hardened and drawn, and fitted and held on *B* as shown; its cutting-face, when the side was advanced, coinciding with the centre of the hole in the bushing *E*. The operating lever *T* was then made, the lug *J* fitting within the hole in the slide *B*, the fulcrum of the lever being held between the two lugs projecting down from the bottom of *A*. A hole was then drilled in it for the adjusting-screw or stop *N* to prevent the tool from going too far. Two stiff pull-springs *N N* were fastened by pins in *A* and *B* respectively, with sufficient tension to bring the slide back when the pressure on the lever was released. The

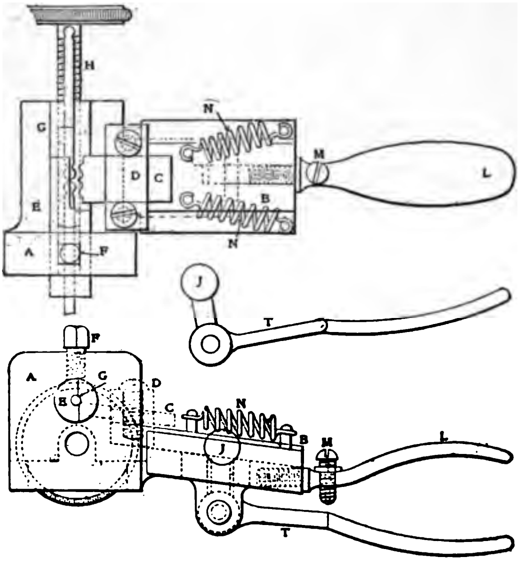


FIG. 368.

parts were then assembled in the way shown. The rod used came in 20-foot lengths, one end of which entered the hollow spindle of the speed-lathe and was allowed to project from the chuck almost four feet. This end was entered within the bushing *E;* the lathe was run at its highest speed and the tool held in both hands. Pressing on the handle, the slide *B* moved far enough to enable the tool *C* to form and finish the first end. The stop *H* was then set and the tool moved along until the finished end rested against it, when the other end was finished and cut off and also the end of the next piece formed, and so on. We

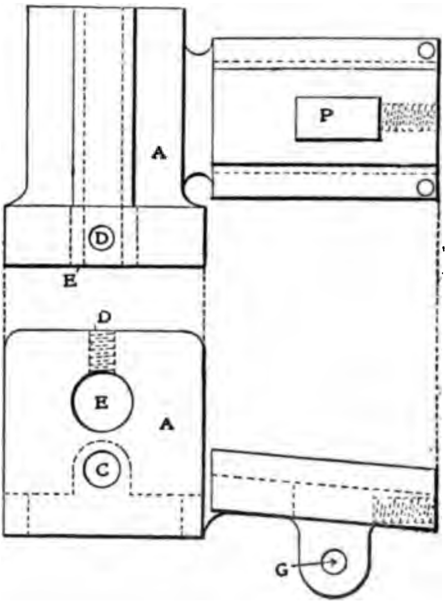


FIG. 369.

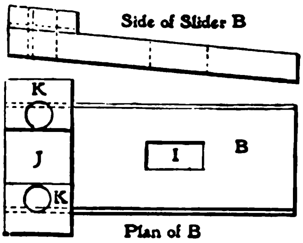


FIG. 370.

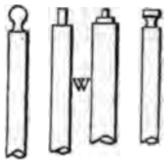


FIG. 371.

cut rods from smallest sizes up to ¼-inch in diameter in this way and beat the other ways by a large margin, the only changes necessary being to replace bushing *E* and the cutting-tool *C* with the others.

MILLING-JIG FOR THE SPEED-LATHE.

The jig here shown in Fig. 372 was used for milling the side at *T* of the piece shown in Fig. 373, which was made in the screw-machine. After the casting *A* for the base was planed on both sides, the two holes *Q Q* were drilled for fastening it to the lathe. The swivel stud *C* of machine steel was then made; the case *B*, of cast-iron, was turned and bored to allow *C* to move freely within it. A ¼-inch slot ¾-inch deep was milled through the centre of the top of *C* and then fastened to the base *B* by four screws. A casting *E* was planed and the vertical slot for the lever *F* to move in was worked out to fit the lever nicely sidewise. An opening was cut away at the farther side, as indicated by dotted lines at *H*, for an outlet sidewise for the lever. The hole for the adjusting-screw *J* was then drilled and tapped in the top and the casting fastened to the front of *A* by screws,

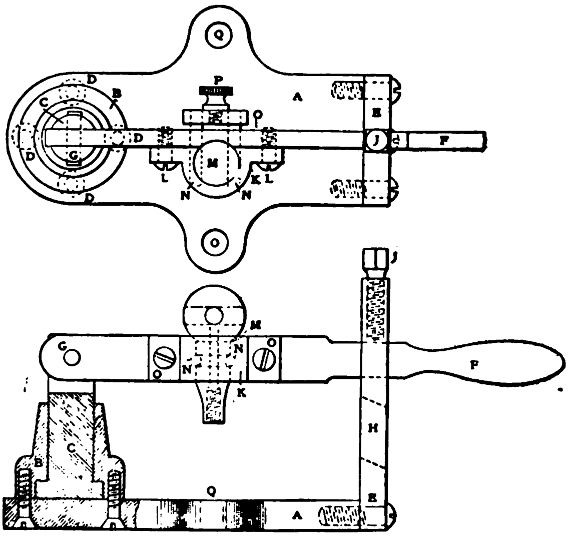


FIG. 372.

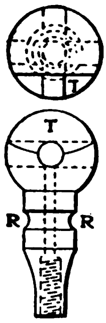


FIG. 373.

leaving the slot for the lever in line with the centre of the stud *C*. The lever *F* was then placed in the slot in *C*, and a hole was drilled through them both for the pin *G* which was tight in *C* and free in *F*. The large parts of the jig being complete, the piece for locating and holding the work was made.

The work Fig. 373 was made in the turret-lathe. The groove *R* around the outside of the piece was as near a perfect half-circle as it was possible to get it, and about $\frac{5}{64}$-inch radius. At first a piece of machine steel was worked down to the shape shown by the outside of *K*. This was then fastened to the outside of the lever *F* by screws and dowel-pins. A hole was then drilled in the centre of this at *M* just the size of the work around the body, this hole cutting partly into *F* as shown, and the shape of the small portion of the head worked out, allowing the work to rest nicely within it. The distance from the centre of the work to the centre of the groove *R* was then found, and the centres located on the side of the lever *F* and two holes drilled through the lever and the piece *K*, cutting half-way into the hole *M*. Two pieces of Stub steel, *N N*, $\frac{5}{32}$-inch in diameter and the proper length, rounded off at the ends, were fastened into a flat steel piece *O* so that they would just enter the two holes at *N N*. A round-head thumb-screw *W* was let in at *P*, enabling this piece to be inserted and withdrawn readily.

The jig being complete, it was fastened to the lathe crosswise and a cutter placed on a mandrel between the centres. The jig was then placed so that the work would come central one way, and off to the side the proper distance the other way. The lever *F* was dropped down and moved sidewise out through the opening *H*. This left the part for the work to go in clear of the cutter. The work was then inserted and the lock-pins *N N* were thrust in, thereby binding the work securely. The lever was then re-entered into the slot *H* and raised to a height sufficient to mill the work to the proper depth, when the top of the lever encountered the top screw *J*. We did quite a variety of different milling and cutting of this kind with this jig.

JIGS AND FIXTURES FOR ADJUSTABLE STOPS AND SPINDLE-RACKS.

Figs. 374 and 375 show in two views an adjustable stop complete, as used on drill-press spindles. As shown, it consists of a casting with the centre hole *A* bored and reamed to fit the spindle of the press at the upper end. It is also drilled at each end for a screw and slotted at *D*. The screw *C* is for tightening it on the spindle. The adjustable stop-screw *F* consists of a knurled screw *F* and a jam-nut, as shown. For the machining and finishing of the casting three operations were necessary.

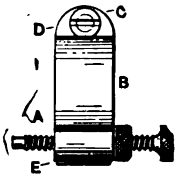


FIG. 374.

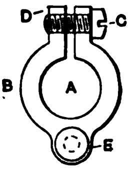


FIG. 375.

For the first, that of boring the centre hole *A* and facing one side at *B*, the special chuck shown in the two views in Fig. 376 was used. It consists of a casting *G* of the shape shown, which was first chucked and a hole bored through it at *L*. This hole was then enlarged and threaded at *H*, as shown, to fit the spindle of the turret-lathe. It was then removed and the face milled and cut away as shown—that is, on the sides *K K* and *J*—and a straight cut to the depth shown through the face at *I I* made.

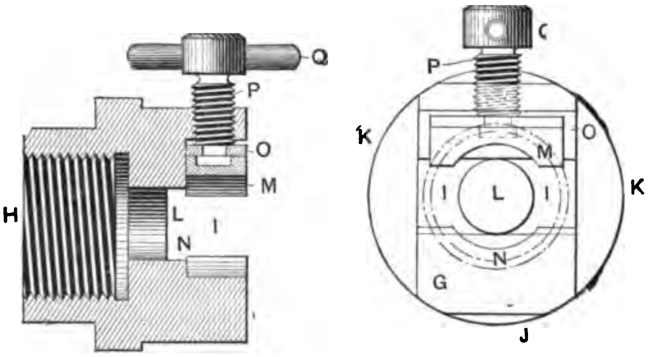


FIG. 376.

A hole was then drilled and tapped for the clamping-screw *P*, which was reduced at one end and fastened within the clamping-jaw *M*, as shown, the plate *O* keeping it in position. The chuck was then screwed on to the spindle of the turret-lathe, a piece of steel placed between the jaws *M* and *N* at each side, and the screw *P* tightened so as to clamp them securely. The two jaws were then bored to the diameter and depth shown, the radius being the same as that of the largest circular diameter of the casting Fig. 375, and in depth so that it would project outside of the chuck enough to allow of it being faced. All this being done, the chuck was finished and ready for work.

When using the chuck the casting Fig. 375 was clamped between the jaws *M* and *N*, and the hole *A* was bored and reamed, by means of the turret-tools, and faced by a tool in the tool-post of the slide-rest. As will be seen, the chuck is suggestive for a number of different jobs on odd-shaped castings, as it is easy and inexpensive to construct, and also rapid in handling and production. It is a type of chuck used quite extensively in the brass-shops, where odd-shaped castings, for various purposes, such as unions, etc., are made in large quantities. When a number of different-shaped pieces—in number sufficient to allow of the necessary expense—are required to be bored and reamed to a given size, the means shown are the best for producing them. The chuck shown can be so constructed, by changing it to suit, as to allow of pairs of different-shaped jaws being inserted in place of the ones in use. The way to do this is to finish the face of the

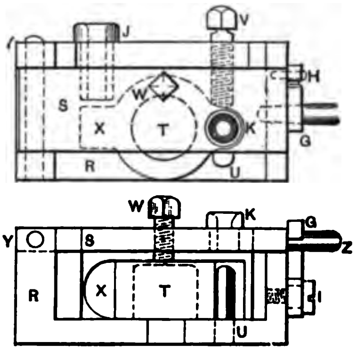


FIG. 377.

chuck with a stiff projection at each side, and dovetail the jaws into them, one of the jaws, of course, being adjustable.

For the next operation on the casting, that of drilling the holes at *C* and *F* respectively, the drill-jig shown in Fig. 377 is used. It requires no description to be understood.

For the last operation, that of slotting the casting at *D*, a simple little fixture for use in the milling-machine is shown, and as the two views of it with the work in position, shown in Figs. 378 and 379, are very clear, very little description is necessary. An angular-shaped casting *A* is first planed and finished as shown, the part *B* as the base to rest squarely within the milling-machine vise. A machine-steel stud *C* is then turned to fit the centre hole *A* in the casting, Fig. 375, and reduced at one end so as to shoulder against the back of the fixture *B*, and riveted tightly within it at *D*, as shown. The pin is for locating the casting squarely on the fixture. A slot is cut through the top in line with the centre of the stud *C* and running partly through it, as shown. This in order to get the slot in the centre of the casting, that is, central with the hole *A*, Fig. 375. In operation the casting is placed on the fixture as shown, and forced against the pin *E*. Both fixture and casting are then clamped in the miller-vise, and the cutter *G* entered into the slot. When the casting is milled, it is removed and another substituted, and the operation repeated. This little fixture is all right, as it allows of the slotting operation being accomplished uniform in all of the castings, giving them a neat and mechanical appearance when finished, and is far superior to the usual way of doing simple jobs of the kind shown, namely, setting the casting central to the eye, and then going ahead, with the ultimate result that there are not two alike.

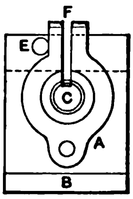


FIG. 378.

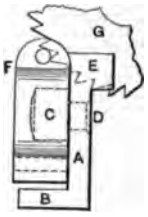


FIG. 379.

MILLING SPINDLE-RACKS.

In Fig. 380 is shown, in three views, a fixture which is used for milling drill-press spindle-racks. And, as it is as practical a device as could be designed for use in the regular milling-machine, it is worthy of interest, handling, as it does, sixteen rack blanks at a time. In design it is both simple and compact and is so constructed that a boy can operate it successfully while running another machine; as when the cutter is set, the time necessary to allow of the cutters running through the entire sixteen blanks can be utilized in looking after a different operation in another machine.

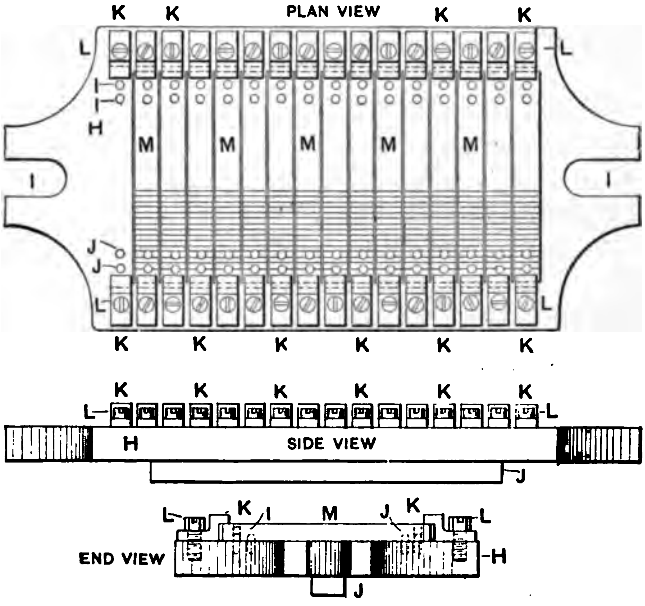


FIG. 380.

In constructing the fixture a flat casting of the shape shown at *H* was first secured—in appearance resembling a die-bolster—was planed smooth on the top and bottom, and the tongue *J* fitted to the slot in the milling-machine table. While planing the tongue a cut was taken off each side, so as to have them square. The casting was then transferred to the milling-machine, when the four rows of holes, sixteen in number, for the dowel- and locating-pins *I* and *J J* were drilled. These holes were for locating the rack blanks, which had been previously milled to size, and the four holes in each drilled in a jig so that they were exact duplicates of each other. In drilling the holes in the casting *H* it was strapped on an angle-plate, facing the spindle, which was in turn clamped to the extension plate on the milling-machine table, taking care to get the casting *H* fastened so that the tongue *J* was parallel with the table. The first row of holes was then drilled by first using a small centre-drill and spacing the holes by means of the dial on the feed-screw of the table, and then drilling them all in the same manner, repeating the operation until the four rows of holes for dowel- or locating-pins *I I* and *J J* were drilled.

In the spacing of the holes, so as to get them in the relation to each other, as shown, great care was taken so as to have them coincide perfectly with those drilled in the racks, as these pins locate the blanks square on the fixture when in use. Sixty-four small pins were then cut off to the length shown, and rounded at one end; they were made of Stub wire and driven tightly into the holes drilled in the fixture, and an easy fit in the holes of the rack blanks.

The small clamps shown at *K K*, of which there were thirty-two, were then made to the shape shown, by taking four bars, long enough to get eight out of each, and milling them to the shape required, after which they were cut into sections, which were the clamps shown. The clamps were then drilled for the screws *L* as shown, and sixteen fastened at each side of the fixture in the position required, so as to grip tightly the ends of the blanks and keep them flat and square on the fixture. The heads of all screws were case-hardened.

The various parts of the fixture were then assembled, and the fixture complete strapped on the milling-machine table by means of bolts through the ends at *I I*, and with the tongue *S* in the centre slot. The sixteen rack blanks were then located and fastened on the fixture by fixing them on the pins *I I* and *J J* and the clamps tightened as shown on the blanks *M* in the plan view of the fixture in Fig. 380. This figure shows the blanks partly finished, the last one being off to show the pins for locating them. Two cutters of the pitch required were used, and the table of the miller raised so that the full cut would be taken. The feed was then put on, and the cut taken through the entire sixteen blanks, when the table was run back to the starting-point, moved over the required number of thousands, and the cut repeated, and so on, until the entire sixteen blanks were finished. They were then removed and another lot located and fastened in the same manner, and the operation of milling repeated.

This fixture overcomes the difficulties which are usually met with when milling one rack at a time, by holding it in the milling-vise. As when it is done in that manner it is necessary to mill all sides of the blank perfectly square with each other, in order to get them to lay flat while being cut, while by the use of this fixture, as shown, it is not necessary to be so particular, as the blanks are held by means of the clamp at either end, and located squarely and in line with each other by the pins shown. Another thing, the setting is easy to accomplish, as it entails no adjustment of the parts.

JIG FOR DRILLING SMALL THREAD DIES.

Some years ago I had a job of making one hundred small thread dies for screw-machine work. To have drilled them in the regular way would have taken a great deal of time and made them very expensive, so I made the jig shown in Fig. 382 for the purpose.

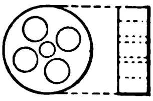


FIG. 381.

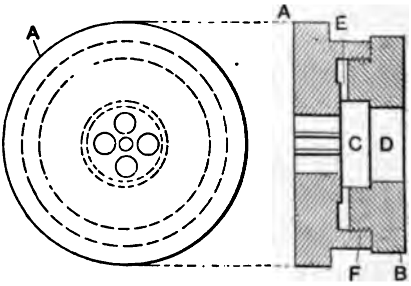


FIG. 382.

First, I turned and finished a bar of steel to exactly the right size for the dies and then cut off the blanks, being particular to get them all the same thickness and also to chamfer the corners. Fig. 381 shows the die blanks, which are ½-inch diameter. Fig. 382 shows two views of the jig, the top and a cross section. The jig was made in the shape of a round box. *B* is a piece of round machine steel turned and finished as shown with a thread of 10-pitch cut at *F* which was cut loose in order to work the jig rapidly. At the same time the seat for the blanks was turned out at *C* so that they would just fit in without play. A hole was then bored through at *D* to give clearance when the drill came through and also to let the chips out. The jig proper *A* was a piece of round tool steel chucked and finished all over in the way shown. The centre hole was drilled at the same time, and a circle was struck to drill the other four holes by. The outside was heavily knurled to give the operator a good grip. All holes were reamed and slightly countersunk to allow the drills to enter freely, when the work was carefully hardened and drawn, being then ready for work. The blanks were laid in at *C*, the cover *A* was screwed down, and the holes all drilled, and another die inserted, and so on with them all. It was surprising how quickly the dies were made by the use of this jig.

CHAPTER XXII.

Special Tools, Fixtures, Devices, Arrangements, Contrivances, and Novel Methods for Metal Working.—*Continued.*

A MACHINE FOR TWISTING CORKSCREWS.

THE machine here shown was made for twisting wire corkscrews of the type shown in Fig. 383. The wire before the twisting is shown below the corkscrew. It is "looped" at one end and bent, while the other end is pointed. The cutting off of the length of wire and the pointing of one end are accomplished in one operation by means of two simple tools in the monitor; the tool used for pointing being a "needle" box-tool, and the one for cutting off a "chopping-tool." The second operation on the wire lengths, that of bending and forming the "loop," is done by hand, with a simple bending fixture not of sufficient interest to show here.

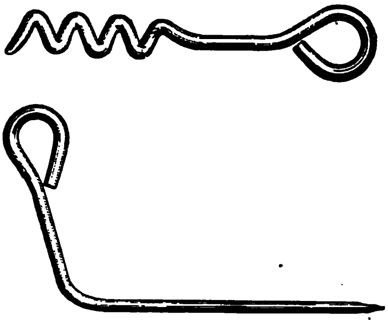


FIG. 383.

The drawings, Figs. 384, 385, and 386, of the twisting-machine show its construction and little description will be necessary. The machine consists of, first, a body or main casting on which are four standards for bearings for two shafts. The pulley, clutch, and small driving-gear require no explanation. The wire is clamped between two jaws *H H*, Fig. 384, the upper one of which is raised or lowered by the handle and two gears *A A* turning right and left screws. The mandrel or forming-spindle *X* is of tool steel finished to fit easily within the sleeve *K*, which in turn is fitted and keyed to turn with the slide, back and forth within the main spindle *V* by a key at *D*. A handle at *Z* fastened to the forming-mandrel by the set-screw *W* keeps the mandrel stationary, by a round-headed pin entering the back at *Y*, while the sleeve with the main spindle rotates and twists the wire. This pin is located in the bracket *T*, with a spring at the back at *S* and a handle at *R* to allow of its being forced back when the mandrel-lever is to be turned.

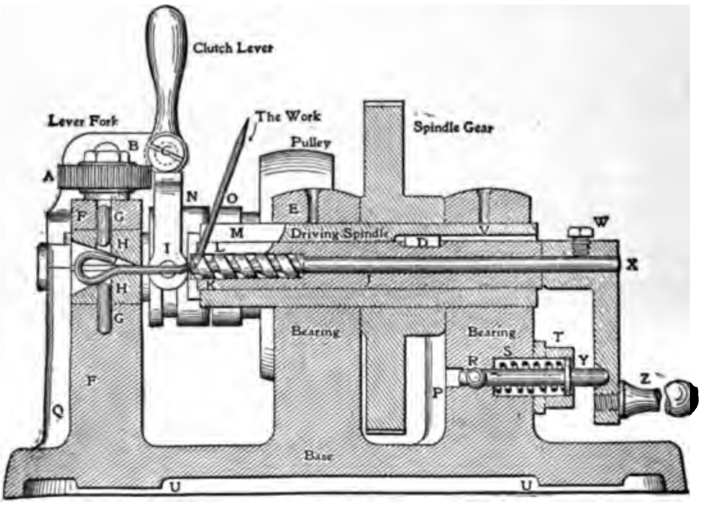


FIG. 384.

When the machine is in use the work is located and clamped between the two jaws *H H*, with the pointed end lying in the slots *L* and *M* of the sleeve *K* and the spindle *V* respectively, and the handle of the forming-mandrel located and held by the pin *T*, Fig. 384. The clutch-lever is then pulled back and the spindle *V* and the sleeve *K* rotate while the forming-mandrel remains stationary, thus twisting the wire around the mandrel to the shape shown in the half-tone. The clutch-lever is then pulled out and the machine is stopped when *Z* is released and turned

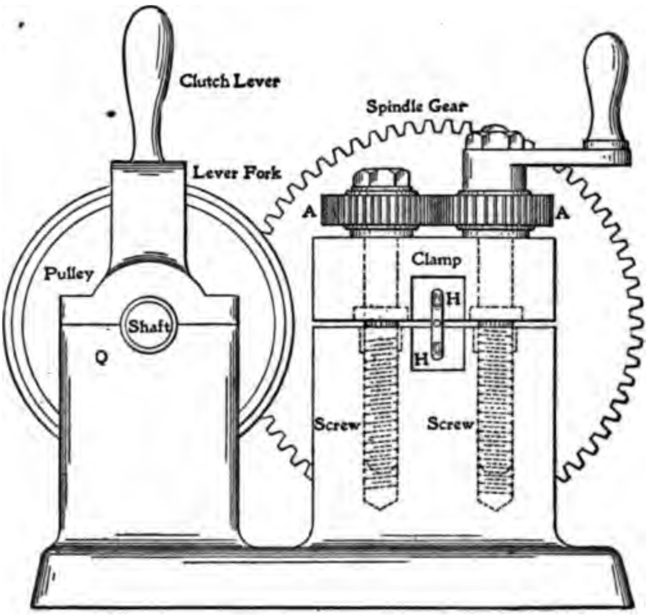


FIG. 385.

toward the left, thus drawing out the sleeve and mandrel, leaving the finished corkscrew so that it can be removed by loosening or raising the upper jaw *H*. The mandrel and sleeve are then slid back in position, another piece of wire is located, and the operations are repeated.

A SPECIAL TOOL FOR CUTTING LARGE FIBRE-WASHERS.

In a shop in Brooklyn, where they make large embossing presses, the rollers of which are made up of fibre-washers forced on to machine-steel shafts, I saw a tool for cutting the washers from the sheets. This is shown in Fig. 387, and the manner of using in Fig. 388. In the shop referred to, two sizes of washers are used; one size 15 inches in diameter with 4-inch hole, and the other 18 inches in diameter with 5-inch hole. The thickness of the fibre board is ¼-inch.

As shown in Fig. 387, the tool consists of a 1-inch drill with a cutter-head beam *B* let through a slot as shown, and fastened by two screws. *C* and *D* are the cutter-heads, which are finished to a good sliding fit on the beam, and *I* and *H* the cutters, which are hardened and tempered and let into split seats in the cutter-heads and fastened by the screws *G*. The cutting-tools are a trifle less than $\frac{1}{16}$-inch in thickness and are given sufficient back and side clearance to allow them to cut freely.

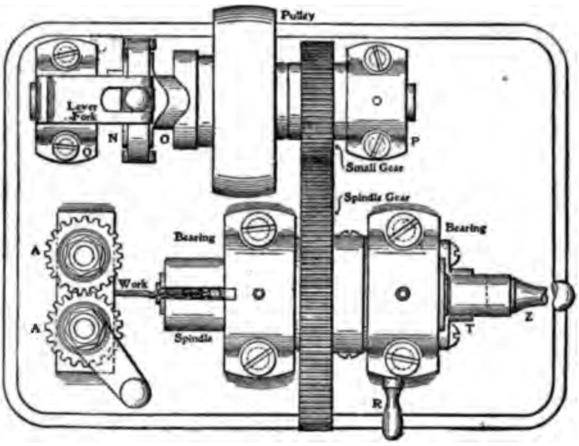


FIG. 386.

Fig. 388 shows how the tool is used. A piece of $1\frac{1}{2}$-inch planking is fastened to the drill-press table, and the table is clamped in a central position. A small pin forced into the planking at the right serves as a gauge for locating the fibre beneath the drill and also to space the washers evenly. The drill-

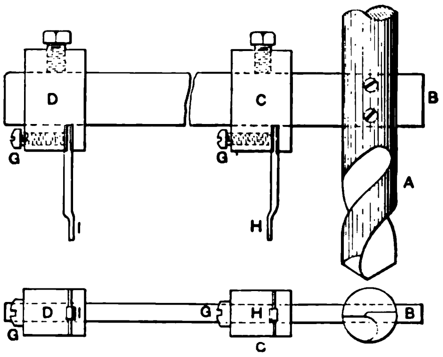


FIG. 387.

shank is fastened in the chuck in the drill-spindle and the tool is rotated at about forty turns per minute. The drill cuts first, and as soon as it has passed through the fibre and entered the wood the inside and outside cutters begin to cut. A slight pressure is all that is necessary to make the tools cut, the shavings curling up nicely, and as soon as they have passed through the fibre a quick raise on the feed-lever causes them to pull free and clear of the work. As will be seen, the tool cuts the inside and the outside of the washer simultaneously, and as the insides are used as washers for smaller-sized rolls two washers really are produced at once.

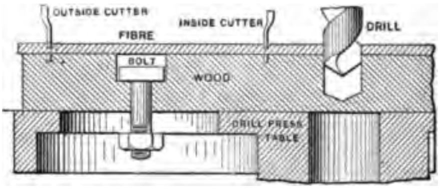


Fig. 388.

AN UNUSUAL AND SPECIAL JOB OF TOOL-MAKING.

Figs. 389 and 390 show a rather unusual job of tool-making, and Figs. 391 and 392 the manner and means used in its accomplishment. The job in question was the making of a tap and die for cleaning out and "sizing" a patent pipe union, the parts of which were of brass and were cast. The thread required in the union was a 1½-inch diameter, $\frac{3}{16}$-inch square thread; and instead of one continuous thread, five were required. Thus the pitch of each thread was 1⅜-inch. This will be understood from Fig. 389, in which the tap is shown as finished. *A* is the first thread, *B*

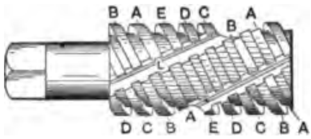


Fig. 389.

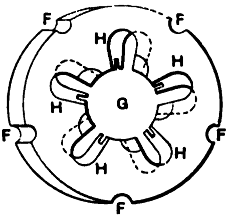


Fig. 390.

the second, *C* the third, *D* the fourth, and *E* the fifth. *L L* are the spiral flutes, of which there were five.

The tap was made first. The means used are shown in Fig. 391 and consist of a small face-plate fitting the lathe-spindle, a dog and a driver. The face-plate had five holes drilled and reamed at equal distances apart on a radius true with the live centre of the lathe. This was done on the dividing-head of the universal milling-machine, first indexing for five, and centring with a stiff centre-drill, then drilling and reaming to size. A driver of tool steel was then turned up as shown, with a stem *Q* threaded for the nut *U*, and turned to fit snugly the reamed hole in the face-plate and to shoulder at *H*.

The dog *T* was also of tool steel, and was finished, as shown, with a broached hole to fit the square on the shank of the tap-blank snugly, so that there would be no lost motion. A set-screw was also let in, as shown, to insure the positive locating and drive.

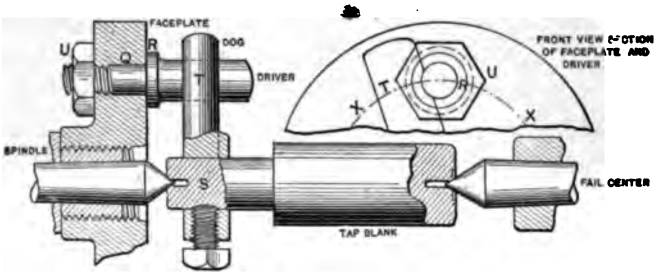


FIG. 391.

The manner in which the tap-blank was held and driven on the lathe-centres when cutting the threads is shown clearly in Fig. 391. The first thread was cut by locating the driver in the first hole in the face-plate. Then the second thread *B* was cut and finished by transferring the driver to the next hole. Thus in succession the entire five threads were cut and the tap finished accurately. The dog was not moved from its position on the end of the blank until the tap was cut. As will be seen, the side of the dog *T* which bears against the driver is hollowed out to the radius of the drive-stem, thus giving a wide bearing surface and insuring a positive drive. A piece of belt lacing, tied around the dog-stem and driver, prevented backlash when the tap-blank was revolving free. In doing the cutting a tool accurately ground to size and clearance was necessary. After being cut the tap was "backed off" slightly and then fluted on the milling-machine, finishing the flutes, five in number, on a spiral, so that the cutting-faces of the thread sections would be at right angles with the pitch, as shown.

After being hardened, the cutting-head was ground, grinding the tap-taper for half its length. Not much lead was necessary as the tap was to be used for cleaning and sizing only.

The manner in which the die was finished can be understood from Fig. 392. The die-blank was 1¼ inches thick by 3¼ inches in diameter. After the outside had been turned to the required size the die-blank was left on the mandrel on which it had been turned, and was set up in the centres of the universal miller. A cutter was then used to mill five equidistant semicircular grooves around the outside, as shown at *O*. Next, another small face-plate, fitting the spindle of the lathe in which the tap had been cut, was bored and finished with a seat at *L L* for locating the die-blank true, and with clearance at *B B* for the thread-tool. A hole was then drilled in the face-plate so as to be dead true with the half-round grooves in the die-blank, and a Stub steel pin driven into it, as shown at *P*. The diameter of this pin was exactly the same as the grooves in the die-blank. Thus

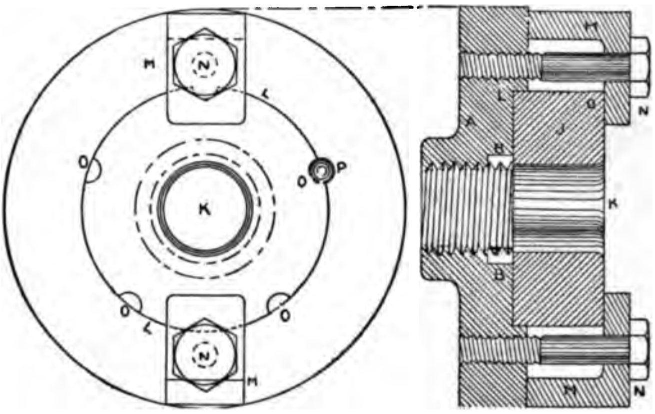


FIG. 392.

the central locating of the die-blank on the face-plate was insured by the locating-seat *L L*, and the spacing of the threads by the half-ground grooves *O* and the indexing-pin *P*. The clamping arrangements require no description, as the drawings show them plainly.

To cut the threads the die-blank was located on the face-plate, as shown, with the pin *P* in the first groove *O*. Thus the first thread was cut. Then the clamps were removed and the die-blank relocated at the second groove, and the clamps retightened and the second thread cut. These operations were repeated until the entire five threads had been finished to within a shade of the diameter of the tap. The die was then removed and sized with the tap.

By reverting to Fig. 390 the reader will see how the die was finished. *H H H H* are holes drilled at an angle with the die-face, so as to have the cutting-faces of the threads at approximately right angles with the pitch. The die was left solid and hardened, and the shrinkage resulting in it allowed of the parts cleaned and sized by the die being an easy fit within the parts finished by the tap.

SPECIAL ENGRAVING-MACHINE.

The machine represented herewith in Figs. 393 to 396 was designed by the writer for the special purpose of engraving moulded composition checks, which are used for a number of purposes instead of money, in sets of exact duplication; this being impossible by the hand method, which was the means used before this machine was designed.

As these check sets are produced in large quantities and as there is always a steady demand for the best quality, the use of the machine here shown proved a great factor in reducing the cost of their production. Its use also allowed of the attainment of results in duplication which were formerly impossible.

The design and construction of this machine is such as to allow of its adoption for a multitude of other uses besides the special one for which it was used. A few of the uses to which it may be adapted by mechanical readers are: the backing off of small gear, ratchet, and other cutters for clock and watch work, the turning of odd-shaped punches, wherever they are used in large numbers, turning elliptical punches and dies, either straight or taper, and the finishing of small circular cams and eccentrics. A number of other uses will suggest themselves to the practical man. The writer has already adapted the principle of this machine, with slight modifications, in a new machine to be used exclusively for backing off cutters for watch and clock pinions.

As the three views of the machine show clearly its design and construction as well as its use, we will confine ourselves to merely pointing out its main features. The construction of the head requires no description whatever, as it is shown clearly in Fig. 396. Reference being made to the three views: the machine consists of the base *A*, on which the bearings *B B* for the head-spindle and those at *C C* for the cam-spindle are cast in two legs to which the base is fastened and the head and slide-rest. In the front-end view, Fig. 394, the check is held in the spring-chuck *G* and the tool *U* set to as shown. The gear *K* on the cam-spindle is the same size as the one at *Q* on the head-spindle and is driven by the intermediate gear *J*. The cam *R* is of tool steel and is hardened and lapped to a smooth finish. The engaging-stud *T* is also of tool steel and is driven into the tool-slide *Q* as shown,

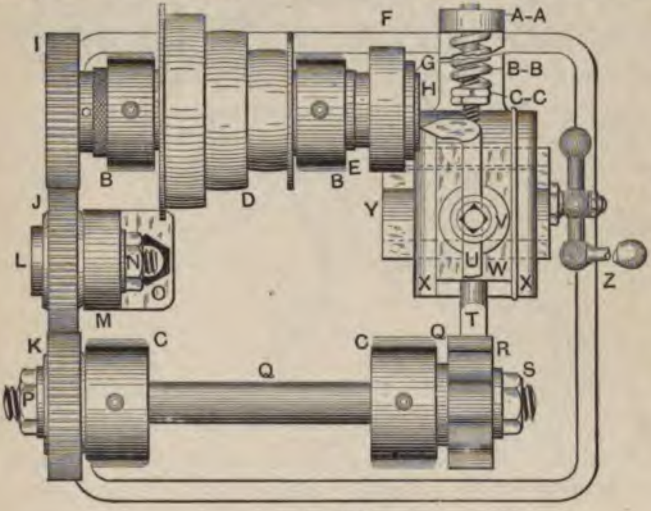


FIG. 398.

and the pointed end rests against the cam *R*. The spring *B B* at the front is of sufficient strength to keep the engaging-stud *T* tightly against the cam face.

When the machine is in use, a check is held in the spring-chuck *G* and the tool *U* set as shown. The machine is then started and the tool fed up to the work by turning the cross-slide handle *Z*. The cam *R* revolves at the same speed as the work and the slide *W* is moved in and out accordingly, the tool producing the results shown. As everything else can be seen and understood from the drawings no further description is required.

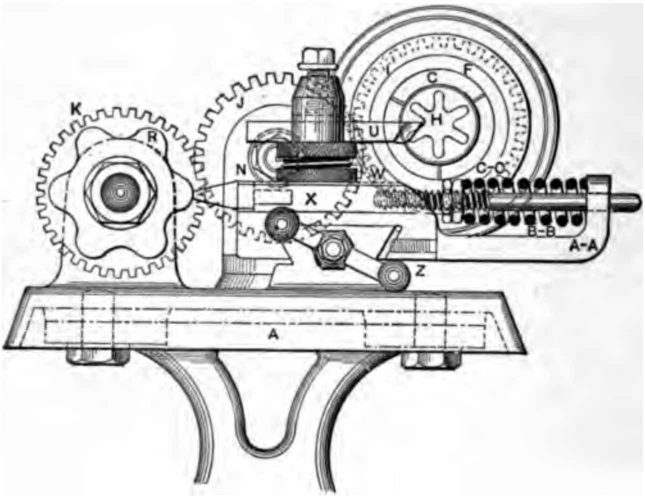


FIG. 394.

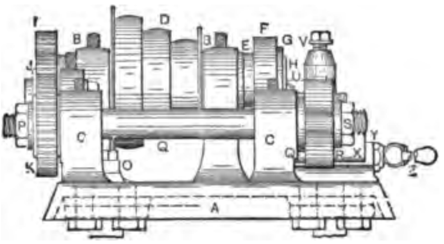


FIG. 395.

In Figs. 397–403 are shown seven samples of checks which were engraved in this machine. For the one shown at *A* a tool with four points was required; for the one shown at *B* a tool with three points; while for *C D E* and *G* tools with two points were used, and for *F* one with one point. For each different design a special cam was made. With the machine a boy turned out four checks a minute, while an engraver working by hand could only turn out one every minute.

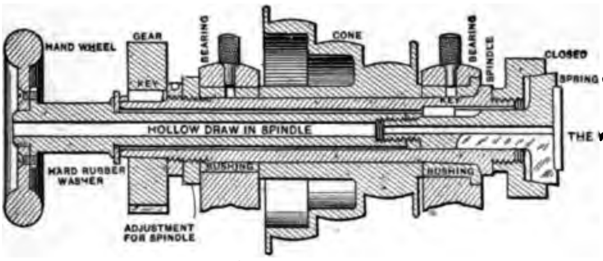


FIG. 396.

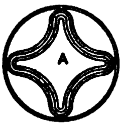


FIG. 397.

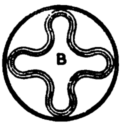


FIG. 398.

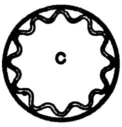


FIG. 399.

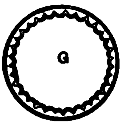


FIG. 400.

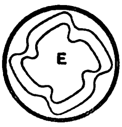


FIG. 401.

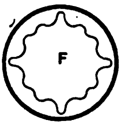


FIG. 402.

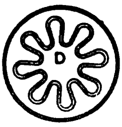


FIG. 403.

SPECIAL CAM-MILLING MACHINE.

Fig. 404 shows a plan of a special cam-milling machine built for milling certain cams used on a printing-press. *E* is the cam as milled. It is in the form of a stepped cone and is fastened to the spindle *B* by the nut *F*. *G G* are the standards in which the spindle *B* is rotated and reciprocated endwise by means of the gear *C* and the master-cams *A A*. *D D* are two lugs projecting up from the base of the machine in which are turn rollers which contact with the cam surfaces.

K K are the standards for the milling-spindle, *L* a cone pulley driven by belt, *M* a worm which turns a worm-gear on spindle *N*, *H* the milling-cutter, *I* a draw-in spring-chuck, and *J* the driving-spindle. *T* is the hand-wheel for feeding in the cutter *H*. The pinion *O* on the worm-gear shaft *N* drives gear *Q*, and pinion *R* drives the large gear *C* on the cam-spindle. Thus the milling-cutter is rotated at a high speed and the work *E* very slowly.

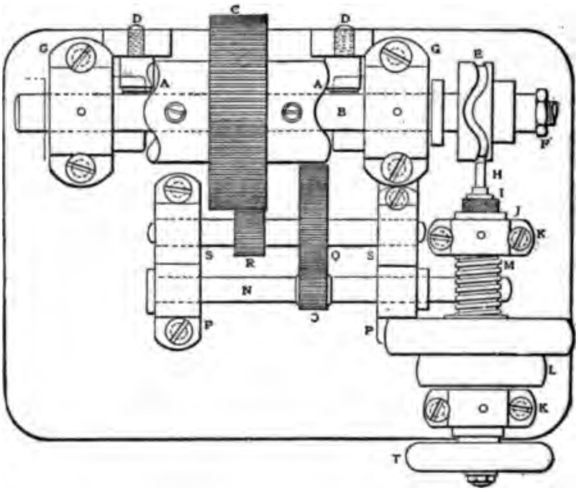


FIG. 404.

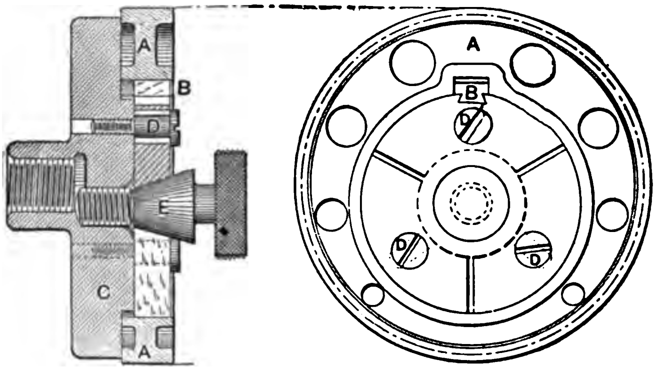


FIG. 405.

CHUCK FOR TURNING ECCENTRIC RINGS.

Fig. 405 shows a chuck used for turning eccentric brass rings of the shape and section shown at *A* in the engraving. They were to be bored out, faced on both sides and turned on the periphery, all dimensions being made to gauge so that the pieces would interchange. In order to turn out the work at a profit it was necessary to design and build a few fixtures for the handling of the work. Two chucks were made for this purpose. The first, which held the ring while the eccentric hole was being bored and one side faced, was of no special interest. After this operation the keyway at *B* was machined with the aid of a simple slotting fixture.

The chuck that was employed for the last operation, that of turning the periphery and facing the remaining side, possesses several features of general interest that may be adapted to other work of a similar nature. This chuck is shown in Fig. 405 holding one of the rings in position to be operated upon. The body of the chuck *C* was threaded to screw on to the spindle of the lathe, and carried on its face three expanding and contracting segments for truing and holding the ring, one of them being provided with a key which fitted the keyway *B* for locating and driving the ring. These segments were held in place on the face-plate by three shoulder-screws *D D D* which passed through radial slots, thereby allowing the segments an in-and-out movement across the face of the chuck. This expanding movement was imparted to the segments by means of the knurled-head expanding-screw *E*, which was tapered slightly so that the tendency when they were tightened or expanded would be to force the work against the face-plate. The clamping surfaces were eased off so that only about an inch of each would bind against the work.

The manner in which the chuck was used and the work machined was as follows: The stud *E* being screwed outward by grasping its knurled head, the segments were contracted. Then the ring was located against the face-plate with the key in the segment fitting the keyway *B*. The expanding-stud was then screwed in and the segments in expanding forced the work tightly against the face-plate and held it securely. It was then a simple matter to turn the periphery to the required diameter and face the side, after which the segments were contracted by unscrewing the expander, the finished piece was removed, and another located ready for machining. As will be understood, the machining of the rings with the usual means handy around the shop would have been difficult and would have consumed much time; while by this method there was no time lost and the complete interchangeability of the rings when finished was guaranteed. It was surprising how easily and rapidly the rings were located and removed and how tightly they were held. As the brass castings from which the rings were finished were not of the best quality, a cut of considerable depth had to be taken, thus putting considerable strain on the segments.

CHUCKING FIXTURE FOR ECCENTRIC STRAPS.

While none of the tools shown in the following are of very unusual construction, they are of interest because of their simplicity and their value in producing rapidly and interchangeably the required parts.

The first fixture is shown in two views in Figs. 406 and 407. It is used in the boring and tapping of the hole *A* in the eccentric strap *B*. The piece is of cast-iron, and the operations performed previous to the one mentioned are the milling of the faces of the two parts of the strap, the drilling and tapping of the two holes in the lugs for cam-screws, the boring of the 4½-inch hole, and the facing of the two sides. The hole is bored and the two sides faced at the one handling by strapping the work on

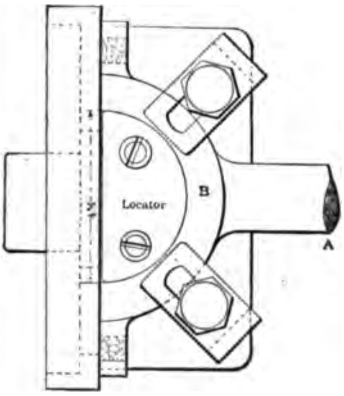


FIG. 406.

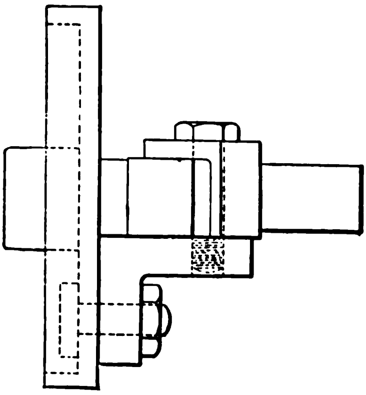


FIG. 407.

the lathe face-plate so that the lugs rest on parallels which are thick enough to allow of using a "hook" tool for finishing the side nearest the face-plate.

The fixture for boring and tapping the hole *A* as shown in Figs. 406 and 407 is very simple and requires but little description. It consists of an angle-iron, which is bolted to the lathe face-plate; a "locator," and two clamps. The "locator" and its use are shown in the plan view. It is fastened to one face of the angle-iron by means of two flat-head screws so that the strap *B* will be located central and true; the planed surface by which the piece *B* is joined to the other section resting squarely against the face-plate. As will be seen, the use of this fixture insures the locating and finishing of the hole *A* centrally, and in line with the large hole in the strap.

TWO NOSE-CHUCKS FOR ECCENTRIC CAMS.

In Figs. 408 and 409 we have two views of a chuck used for the first operation on an eccentric cam. It is of cast-iron, bored and threaded at the back, and bored eccentric at the front for the stem *I* of the cam. This eccentric hole was laid out with the height-gauge and "buttoned," and then indicated on the lathe face-plate and bored. A pin *J* locates the cam properly and assists in driving it while the surfaces *K* and *L* are being machined. Two set-screws equipped with brass ends are used at *M* to secure the stem in the chuck.

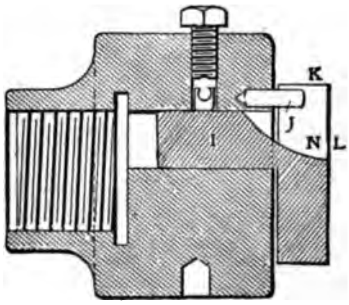


FIG. 408.

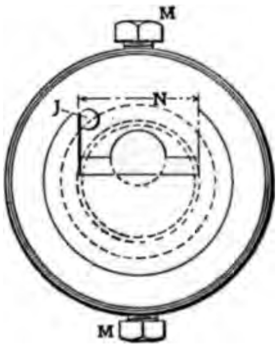


FIG. 409.

The next operation on the cams is the milling to size of the portion indicated at *N*. For this a simple little device (not shown) in the form of an angle-iron with a seat upon which to clamp the machined portion of the cam is used.

For the third operation, which is the last, the chuck shown in Fig. 410 is used. As will be seen, this is of much the same design as the other, except that it is equipped with a "locator" which fits the milled channel *N*. Two set-screws fasten the work in the chuck.

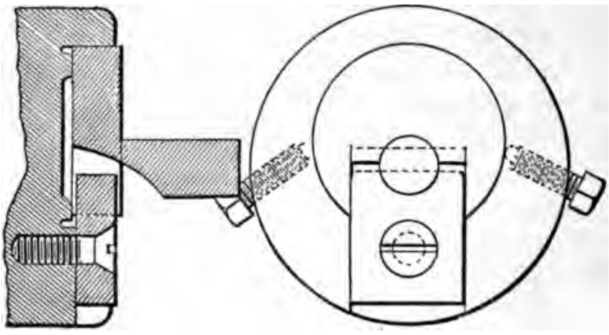


FIG. 410.

It is obvious that with these two chucks the production of cams that are interchangeable is not difficult, and at the same time it is possible to machine them rapidly.

FIXTURE FOR CHUCKING GASOLINE-ENGINE CYLINDERS.

The chuck shown in Figs. 411 to 413 contains some points of interest that may be adapted to the rapid production of any work of a character similar to the pieces for which the fixture was designed. The casting for holding which this chuck was made was, as will be seen, of rather unusual shape. It formed a triple cylinder for a high-speed automobile engine which was being manufactured in large numbers. It had three cylinders *B B B*, which were required to be bored out and reamed to size at *C*, turned on the outside at *E*, and counterbored and tapped for plugs at *D*. The portion indicated by the letter *A* was the hub. The centres of all three cylinders had to be on the same plane and spaced so as to form exactly the same angle with each other.

The construction and use of the chuck will be seen by reference to the three views shown in the illustration. *G* is a face-plate, turned and finished to screw on to the lathe spindle and channeled down the face to allow of locating the angle-plate *H*, which was fastened to it by the cap-screws *K K K*. The hub of the casting was first held in another chuck and bored out on the inside and finished on the outside to gauge. This preliminary work formed the basis for the accurate accomplishment of all the succeeding operations. The work was then located centrally on a boss *F* formed upon the bracket *H* so that the three cylinders would come approximately central. For clamping, the three straps *N N N* were used; while the indexing was accomplished by plug *K*, Fig. 412, whose locating part was hardened and ground to fit the finished bore of the cylinder, and also the reamed hole in the lug *J*.

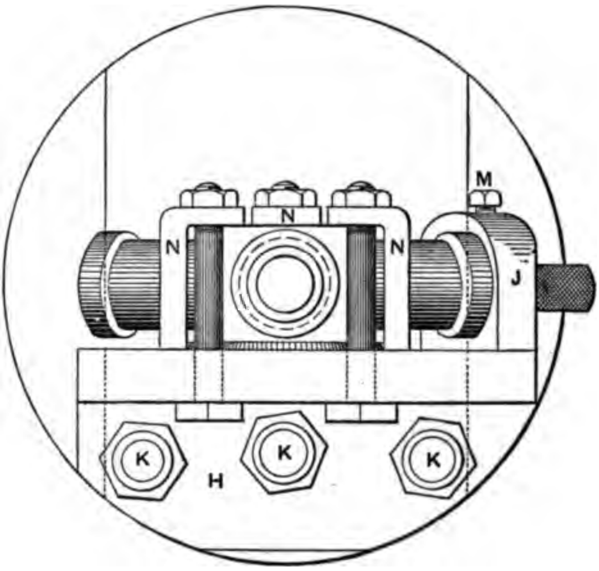


FIG. 411.

When using the chuck, a casting was first clamped somewhat loosely upon the angle-plate *H*, being located centrally by the stud *F*. A plug, which for a distance along its length fitted the reamed hole in the lug *J* and for the rest of its length fitted the cored holes in the cylinders loosely, was inserted, through the lug, into one of the cylinders. The clamps were then tightened and the machining proceeded. First the outside of the cylinder was turned at *E E* to gauge, after which the steady rest was brought up and adjusted so that the finished portion ran true within it. This was followed by the boring and reaming, which

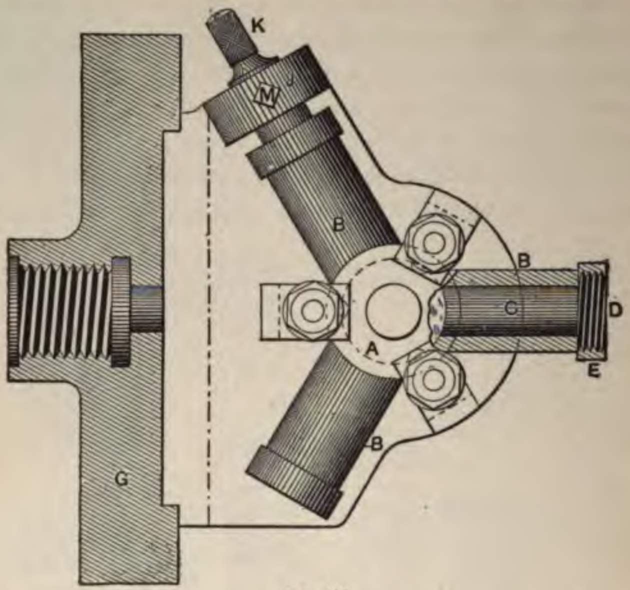


FIG. 412.

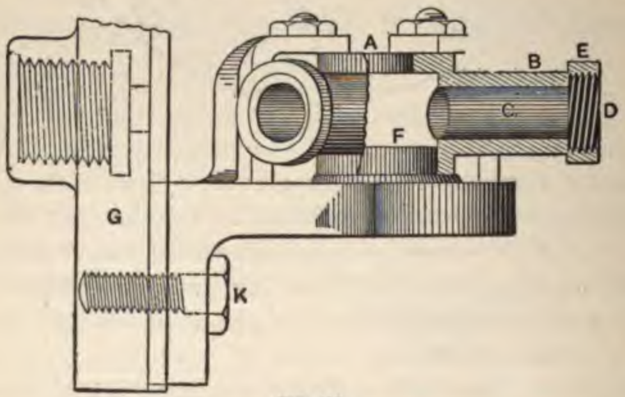


FIG. 413.

was done by first using a bar with an inserted cutter, then a shell-rose reamer, and finally a one-bladed reamer for finishing. After reaming, the counterboring and tapping were done. Now the clamps were loosened and slid back, the work removed from the angle-plate—the temporary plug having, of course, been first removed—and the casting relocated with the finishing-cylinder in line with the lug *J*. The plug *K* was then inserted, through the lug, into this cylinder, which it fitted perfectly. The set-screw *M* was tightened, thereby holding the plug securely in place, after which the clamps were secured and the second cylinder was bored, reamed, counterbored, and tapped as had been done with the first. After this the same method of procedure was followed for finishing the third, or remaining, cylinder.

SPECIAL MILLING- AND DRILLING-JIGS.

Fig. 414 shows a casting which formed part of a clutch for a perforating machine. The jigs shown in Figs. 415, 416, 417, and 418 were used in its production. The castings were $4\frac{1}{2}$ inches in diameter by $3\frac{1}{2}$ inches long, with a cored hole in the centre.

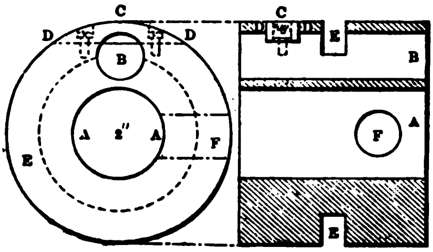


FIG. 414.

The work to be done consisted, first, of boring and reaming the hole *A A* to 2 inches, facing both sides, turning the outside, and cutting in the groove *E E*. For this plain lathe no fixtures were necessary. The further operations required were: Boring the hole *B* for the sliding clutch-pin, milling the slot *D D* for the feather *C*, and drilling the hole *F*.

For drilling the hole *B* the jig Fig. 415 was used. The cast-iron body or base is machined on the bottom to bolt on to the table of the drill-press. This body casting has a stem projecting up from the centre which is turned to fit the hole *A A* in the work, and is tapped at the top to admit the bushing-plate clamping-screws. There is a machined seat for the work to locate on. The body of each clamping-screw enters the locating-stem for a certain distance to insure the locating of the centre of the hole *B*.

The milling of the slot *D D* in the casting and the drilling of the hole *F* were accomplished by the jig shown in Figs. 416, 417, and 418; Fig. 416 showing it as used for the milling of the slot, and Figs. 417 and 418 when drilling the hole *F*.

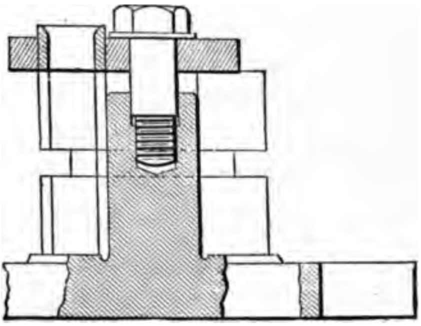


FIG. 415.

The fixture consists of an angle-plate with a central locating-stud fitting the centre hole of the work. This stud is tapped for the fastening-screw. To locate the work on the jig so that the slot *D D* when milled will be properly located, the hole *B* in the work is utilized, a steel pin in the jig fitting it. This pin is made to fit the hole in the work and two holes in the fixture easily to allow of its removal and re-use in locating the work in position for drilling the hole *F*. To expedite the locating and fastening

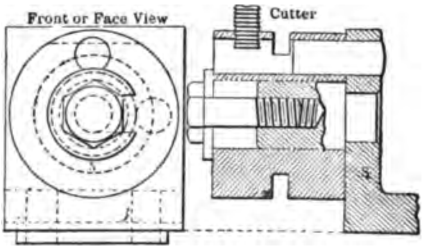


FIG. 416.

of the work on the fixture and its removal when milled a clamping-washer with a section cut out is used, thus allowing of merely loosening the screw and slipping out the washer when removing the work. When in use the fixture is located on the miller-table and held by two bolts, the tongue fitting the central groove of the table.

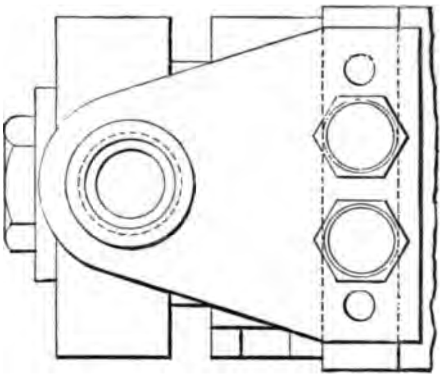


FIG. 417.

The manner in which the hole *F* is drilled is clearly indicated by Figs. 417 and 418. As will be seen, all that is necessary to allow of using the fixture for this operation is the locating of the

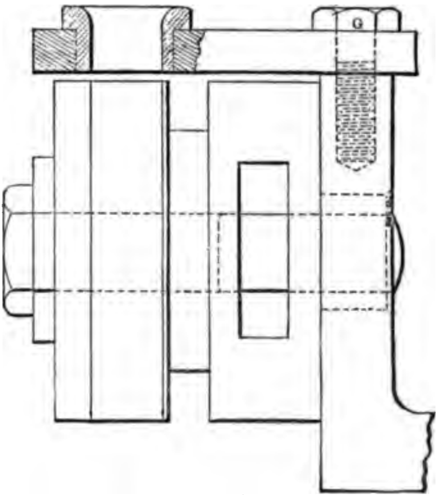


FIG. 418.

stud in *B* and the locating and fastening of the bushing-plate *I* on the top of the body casting. *G G* are dowels, *H* a cap-screw, and *J* a bushing. As the hole has only to run into the centre hole *A* of the work, the presence of the screw *W* does not interfere with the drilling. Although the fixtures are very simple and inexpensive they are great labor savers.

A SET OF JIGS FOR MILLING AND DRILLING.

In Fig. 419 we have three views of a cast-iron punch-head used on gang eyelet-perforating machines. These punch-heads are required to be machined accurately so as to be interchangeable, and are handled during the course of manufacture entirely by jigs. While the work done by the use of these jigs is very accurate and is accomplished rapidly, none of them are intricate or expensive. The piece shown is about ten inches long over all.

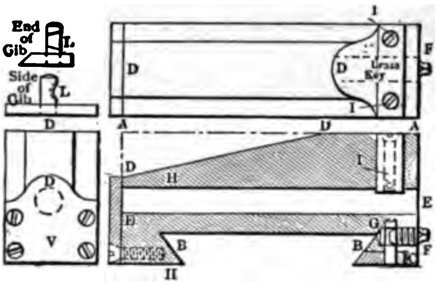


FIG. 419.

The punch-head consists (not counting screws) of four parts: The head proper, of cast-iron; the back-plate *V*, of machine steel; the punch-key *I*, of brass; and the gib at *C*, of machine steel. Leaving the smaller parts, we will take up the machining of the head proper.

The work required to be done on the punch-head consists of milling all sides square and true, milling the dovetail *B B* and the gib-way *G*, milling the angular-formed face *D D*, drilling and reaming the long central hole *E E*, drilling four holes *H* for fastening the back-plate, two holes for fastening the brass key, one hole for the gib-tightening screw *F* and another clearance-hole for the gib-pin *G*.

The castings for the heads before machining were square all over except for the dovetailed and gib surfaces, which were roughly cast.

The first operation was accomplished on a large milling-machine by means of a supply fixture, and a large inserted tooth-milling cutter handling ten castings at a time. This fixture is not illustrated.

For milling the dovetail and gib-way the jig Fig. 420 was used. This accommodated eight castings. The work is located on a machined seat. *P P* are the side-locatings, *L L* the lugs for the side-fastening screws, and *N* the projection in which the end-fastening screws are located. With this jig the vertical milling attachment was used. First the dovetailed slideway was machined with an angular cutter, taking two cuts, one at each side; then the gib-way *C* was machined by substituting a suitable cutter for the angular one. As all the surfaces of the castings were perfectly square and to size, the milling in this operation was done very rapidly.

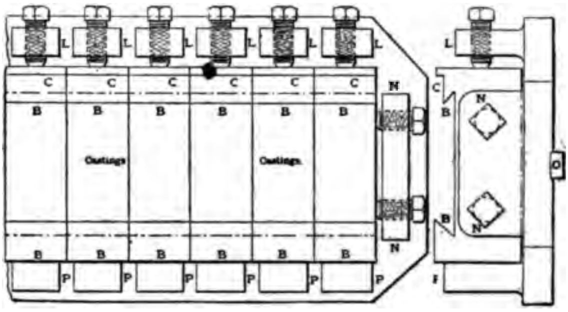


FIG. 420.

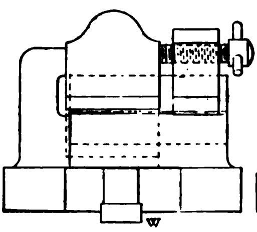


FIG. 421.

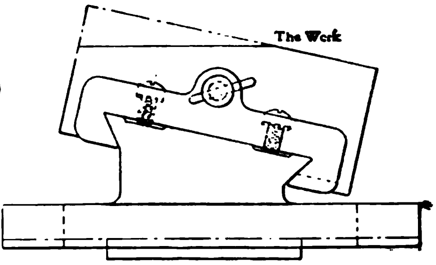


FIG. 422.

The milling of the inclined formed face *D D* of the castings was done by handling one casting at a time in the jig Figs. 421 and 422. The amount of material removed in this operation is indicated by the dotted lines. A large formed milling-cutter was used for this work.

Operation fourth was the drilling of all the holes in the head casting. This drilling was done before milling the keyway for the brass key, because the long central hole *H H* had to be perfectly straight and reamed to size.

Fig. 423 is a plan partly in section of the jig. It is of the box type with cast legs *L* on four sides. The work is located by means of the dovetailed locator *N N* on a machined seat in the bottom of the jig, and is secured by means of a swinging strap, not shown, hinged at *X* and fastened at *Z* by a thumb-screw. The locator *N N* is of machine steel, fastened to the inside of the jig side by two dowels *C*. The bushings for drilling the long hole are removable. They are notched at the side for the knurled-head locating-pins *R*, which prevent them from turning or falling out. The hole *H H* is drilled from both ends, half way from each. When reaming, the two-drill bushings are replaced by others. One at the bottom fits the reamer, while the upper one fits the stem. In reaming this hole a shell reamer reversed is used, so that the cutting-end is upward and the hole is reamed from the bottom.

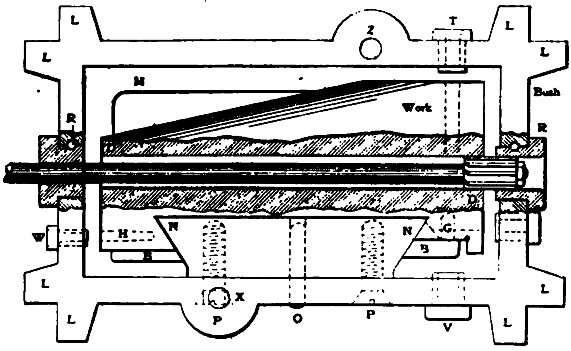


FIG. 423.

For milling the cross-slot or keyway, the jig shown in Fig. 424 was used. This was made to hold a number of castings at once. The work is located and fastened positively and with ease, and its removal when finished is quickly accomplished. The clamp shown at the front end is so made as to allow of locating it quickly by means of the small latch *P* which is hinged in the clamp at *K*. By simply pressing back the handle of this latch the clamp is released and may be slid off.

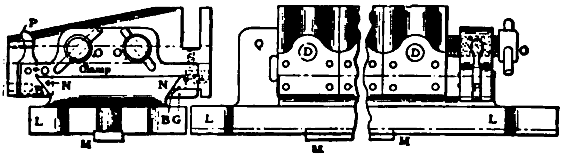


FIG. 424.

By reverting to Fig. 419 the machining required for the small parts will be understood. First, we have the back-plate *V*. This is of machine steel and is first milled and squared all over, the milling of the formed edge to coincide with the formed face *D D* of the punch-head being done after the drilling of the four screw-holes. Then we have the brass "key." This is cut from the bar and cleaned up to size. The drilling of the two holes *K* in the brass key and the four *J* in the back-plate are all done in the one drilling-jig, Fig. 425. The jig is made to accommodate a plate at one end and a brass key at the other. The body casting is machined so as to leave locating-seats for the work and with a channel across it for the piece *O* against which the work locates. The bushing-plate is fastened to the body by four flat-head screws.

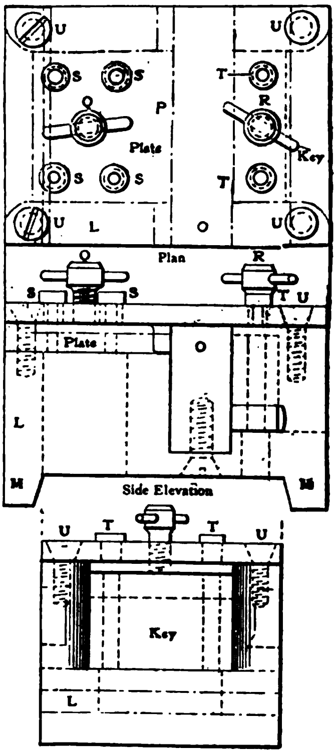


FIG. 425.

S S S S are the plate-drill bushings and *T T* the key-drill bushings. *M M* are the jig legs cast on the body. *Q* and *R* are two screws for fastening the work on and against the locating surfaces. The work is slipped in at the ends; then the screws are tightened and the holes are drilled.

The remaining piece shown in Fig. 419 is the gib. This has a pin which is grooved out at one side to coincide with the taper-point of the gib-screw *F*. When the screw is tightened it forces the gib in and thus clamps the head in position on the perforating-machine. This gib is of machine steel and is milled to size in the miller-vise, an angular cutter being used to taper the edge. For drilling the hole for the pin *L* a simple little slip-jig is used.

The tools shown possess no novel features, nor are they of intricate construction. However, they are interesting and should prove suggestive for other work, as they illustrate how accurate repetition work may be done rapidly and cheaply if some thought is given to the devising of simple and inexpensive tools.

FACING AND COUNTERBORING LARGE SPIDER CASTINGS IN THE DRILL-PRESS.

In a shop where paint-mixing machines are built the writer came across a method of facing and counterboring large castings in the drill-press which may prove suggestive to readers for the machining of other work in a like manner. An idea of the shape and size of the castings may be gained from Fig. 426, in which is

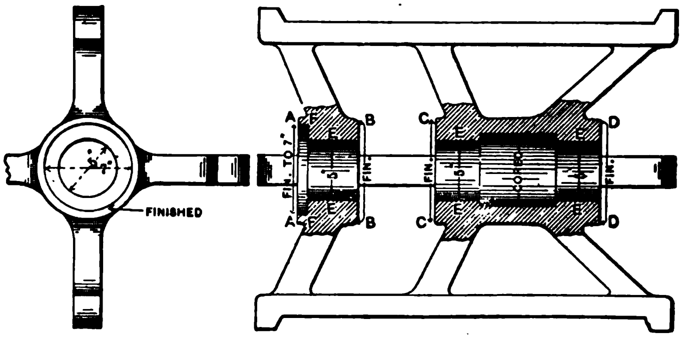


FIG. 426.

shown the nature of the work to be done. As will be seen, the casting has two hubs which are required to be bored to a finished diameter of five inches, then faced at *A A*, *B B*, *C C*, and *D D* respectively, and, lastly, counterbored at *F F* to a depth of one inch and a diameter of seven inches. It is at once obvious that the large drill-press which is equipped with a floor base is the proper machine for the work, and that it would be very difficult to do the work in any other machine.

The boring to a finish of the cored holes in the hubs presented no unusual difficulties; a large boring-bar of approved construction being used and the projecting end allowed to run in a bushing bolted to the floor base of the drill, to which the work was strapped. To accomplish the facing of the four hub faces and the counterboring of the seat in an expeditious and accurate manner, however, required other means than those used for the boring. It was for this work that the special facing and counterboring tool illustrated in Fig. 427 was used.

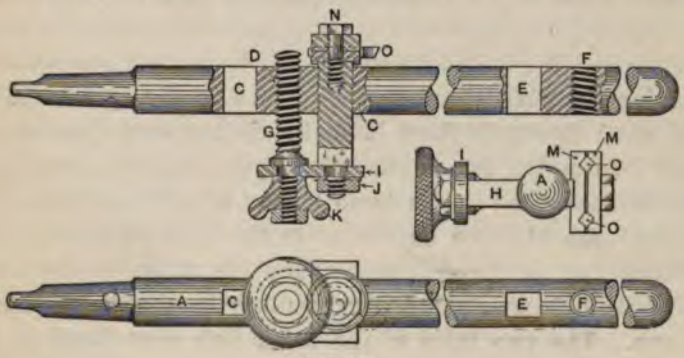


FIG. 427.

As will be seen, the special tool consists of the regulation bar, turned taper at one end to fit the drill-press spindle, and rounded at the other to enter easily the supporting bushing on the base of the press. This bar has five holes let though it to accommodate the boring-head. The holes are indicated in the engravings by letters *C D E* and *F* respectively. Three holes are for the cutter-bar and the other two are tapped holes for the feed-screw *G*. In the cutter-head, *H* is the bar, *O* the "goose-neck" cutting-tool, a seat for which is provided in the cutter-clamps *M* at either side of the centre as the taking of under and upper cuts necessitates. *I* is the connecting strap between the cutter-bar and the feed-screw, *J* the bar-fastening nut; *G* the feed-screw and *K* the hand knob. *N* is a cap-screw used for fastening the cutter and cutter-straps to the cutter-bar.

In using this tool the bar was projected down through the hubs of the casting until the end ran in the supporting bushing at the base. The cutter-head was then in the position shown in Fig. 427. First the surface *A* was faced, the feed-screw being turned a little by hand at each revolution—the large opening making this an easy matter. Next the seat *F F* was bored and finished in the same manner, feeding the spindle of the drill down for depth and the feed-screw of the cutting-head for diameter. After this the under face of the upper hub was faced by removing the cutter-head entirely; feeding the spindle downward until the upper three holes in the bar were clear of the under face of the upper hub; then relocating the cutter-head with the feed-screw in the same hole as it occupied in the first instance; but with the cutter-bar in the upper hole *C*. Thus the cutter-bar was merely reversed and the facing of the under side of the hub accomplished by feeding the spindle up instead of down. The two faces of the lower hub were faced in the same manner, the cutter-head being removed and reversed as required.

CHAPTER XXIII.

Special Machines for Accurate Work on Dies; Their Use.

PROGRESS MADE IN THE USE OF POWER-PRESSES.

IT must be gratifying to mechanics who are interested in the cheap and accurate production of metal parts to note the wonderful progress that has been made in the use of the power-press during the last few years. In fact, the time has arrived when this modern machine has demonstrated its efficiency, when used in conjunction with suitable dies and fixtures, for producing parts of steel, iron, and other metals at a lower cost to the manufacturers and to a finer degree of interchangeability than it has heretofore been possible to attain by other means.

Where the power-press has been adopted for the production of metal parts, and where the full value of dies is understood and appreciated, the machines in which they are used have become as important factors in production as any of the other machine tools in general use. The only reason for their non-adaptation in other establishments is that their use is not understood. There are a great number of shops, both large and small, in which duplicate small parts of standard shapes and sizes are being constantly made, by milling, drilling, filing, or other means, that could be produced at a greatly reduced cost and to a higher degree of accuracy by means of suitable dies in the foot- or power-press. In such shops, the use of the product of dies, that is, using sheet-metal blanks instead of castings where practicable, would cause the people who are responsible for results in such shops to first open their eyes and later to double their production and profits.

HAND-FINISHING VS. MACHINE-FINISHING OF DIES.

While numbers of special machines and devices have been invented for the making of all kinds of other tools, hand-work, to a greater or less degree, has been depended upon for the making of dies, from the simple blanking type to combinations of the tools. The advent of the vertical attachment for the universal milling-machine helped some; but what was wanted was a machine which would do the work which it was then only possible to accomplish by the hand of a skilled mechanic with a file. Thus, to a certain extent, the use of dies has been prevented by the expense which would be incurred in the making of them. This excuse, however, is now no longer operative, for there are now machines which will do the work on dies formerly only possible by hand labor. I refer to the various die-shaping and milling-machines which are now on the market.

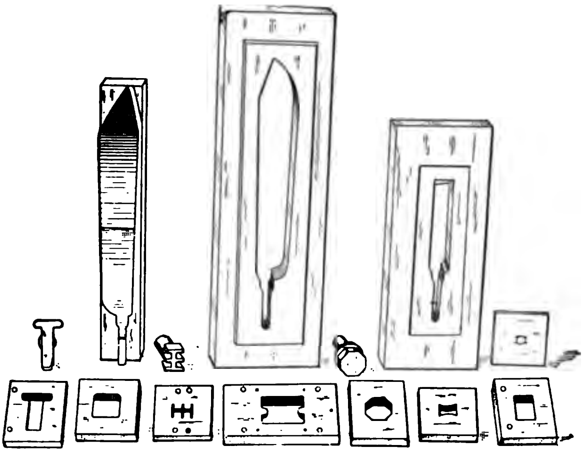


FIG. 428.

The value of these machines to all concerns in which many dies are made may be judged from Fig. 428, in which are shown a number of dies of different types which were machined and finished, up to the point of hardening, by the use of a die-milling machine. Every die-maker knows the skill necessary for finishing such dies by hand, especially in giving the proper or required degree of clearance all the way through. By the use of machines of the type mentioned above, this can be accomplished with ease; and dies which are required to be straight, or tapered slightly inward, as is necessary in burnishing-dies, may be finished with no more trouble than would be involved in the finishing of a die with excess clearance.

USE OF DIE-MILLING MACHINES.

The die-milling machine may be used for roughing out and finishing, to within a thousandth of an inch or so of the templet lines, any kind of blanking-, trimming-, or punching-dies, such as are required to produce silverware, jewelry, bicycle parts, drop-forgings, typewriter parts, sewing-machine parts, etc.

A type of die-milling machine now in use in a number of die-shops is so constructed that the frame of the machine is supported on trunnions, or gudgeons, which hold it in any desired position, so that the operator may have the best possible light on the surface of the work. The spindle is perpendicular to the machine face and is adjustable. When arranged for milling blanking-dies the cutter projects through an opening in the chuck in which the work is clamped, and is straight or tapered to suit the amount of clearance required in the die. When such machines are used it is only necessary to drill one hole through the die-blank, and the cutter, starting in this hole and following the outline of the templet, removes the entire centre in a single piece. The chuck, or work-holder, on such machines is moved in either direction by means of two slides at right angles to each other and, by the use of hand-wheels on the feed-screws, the outlines of the templet on the surface of the work are accurately followed. To assist in doing this there is a pointer at the right of the work which remains at a fixed position with reference to the cutter when the latter is below the surface of the work, and indicates its exact position. This is a convenience in cases where a sharp corner is to be made, when the cutter can be lowered and the cutting continued, guided by the pointer, thus leaving very little to be filed.

Although die-milling machines are not built usually to take very large work, they will take blanks or forgings up to ten inches wide by two inches thick and any length.

DIE-SINKING ATTACHMENT.

In connection with machines for die-making, a die-sinking attachment may be used, and if a great number of dies are required to be sunk, one of them is worth having. By the use of the die-sinking attachment, the skill and knowledge necessary to the successful use of small chisels, gravers, riffles, and other tools of the hand-die sinker, are not absolutely necessary, and a good die-maker will have no difficulty in doing the best work in this line. As these attachments can be attached to die-milling machines in a few minutes, the machine is converted into a die-sinking machine.

MACHINE FOR FILING DIES.

In a number of shops known to the author they have also a special machine for filing the dies worked out in the die-milling machine. This machine is used for filing to a finish all kinds of blanking-, trimming-, punching-, and irregular or square-shaped drawing dies, or anything of that kind that has to be filed accurately.

By adjusting the table of this machine to a graduated plate, any desired clearance from one to ten degrees can be obtained. By setting the machine at zero, the walls of a drawing-die, a burnishing-die, or an accurate trimming-die can be filed or lapped perfectly square, something that is impossible by hand, even by the most skilful die-maker. In these filing machines care must always be taken to have the upper end of the file supported by adjusting a rest provided for that purpose. The amount of stroke in machines of this kind can be readily adjusted by a slot-headed screw in the driving-disc, carrying it further from or closer to the centre, as the work may require. For fine filing a short stroke is desirable.

The samples of die work shown in Fig. 428 are only a few of the large variety of dies which can be finished in half the time and at half the expense usually required when other means are used. Although it is a fact that skilful workmen can often accomplish the most astonishing results with tools which are far from being what they should be, an equipment of up-to-date tools is always to be desired in any line of mechanical work.

A DIE-SHAPER.

The line drawing (Fig. 429) shows in use a device which practically converts a milling-machine into a vertical shaper, or, as usually miscalled, a slotting-machine. It is especially serviceable in working out dies for punching-presses, following any outline, regular or irregular, and giving the required clearance all around. As will be seen, the attachment may be used upon any milling-machine of the standard type, and when once fitted may be slipped on or off as required.

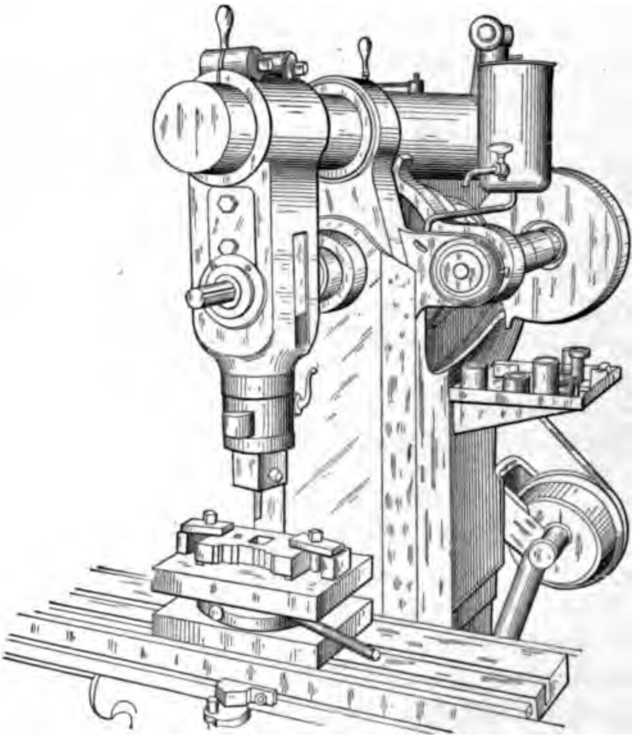


FIG. 429.

The large vertical casting seen in front clamps on to the overhanging arm of the machine, and a spindle below is driven by a taper-shank which fits the machine spindle. Between the two bearings which are provided for this spindle it has secured to it an eccentric or cam which operates a horizontally sliding block which works in the cross-slot of a vertical slide carrying the cutting-tool. The vertical stroke obtained is 1¼ to 1¾ inches, as desired. The cutting-tool is made of ½-inch round steel, secured in the socket by a set-screw. This tool socket is separate from the vertical slide, and when the tool is set it may be turned around as required, so that any outline may be followed and all corners may be worked into. A clapper-block has been provided which gives perfect clearance for the tool on the up-stroke.

The drawing shows the tool at work upon a half-die of irregular outline. This die is mounted upon a tilting-chuck which accompanies the attachment and provides the necessary clearance-angle for die work.

It will be noticed that the middle face between the rings is oblique and by turning these the pitch is thrown in the different directions required, a locking-pin, a clamping-screw and a bar for turning the rings being provided. The central post has a spherical head, so that it can incline as the angle requires.

A SMALL DIE-SLOTTER.

The machine shown in Fig. 430 is suitable for all such work as small key-seating, die-slotting, both straight and taper; also internal or external gear patterns where draft is required, and all that class of common slotting shown in Fig. 431.

The two cross motions and the rotary table provide for following any outline.

The handle for the rotary table is arranged for using dials for dividing purposes, but for small divisions and rapid work it may be entirely removed, and the table revolved by hand, using the locating device, which provides twelve divisions for square, hexagon, octagon, etc.

The stroke of the machine has been fixed at 2½ inches, which is ample for the class of work for which the machine is intended, and affords greater strength than an adjustable pin.

The speed can be changed by means of the cone pulley.

The slide for the ram can be swiveled five degrees either way and set by a graduated index, thereby insuring the same draft to every part of the die. The tool-block is well adapted for holding special tools. It swivels in a centre near its lower end, and at the upper end, carried in a yoke, are two hardened plugs which bear on a cam that is bushed into the lower end of the connecting rod, and from it derives a partially rotary motion, thus locking the tool-block on the down stroke and causing the tool to clear on the up strokes.

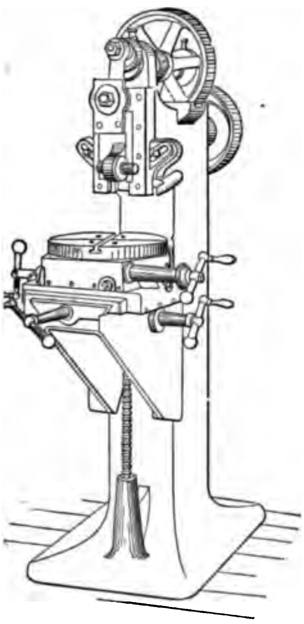


FIG. 430.

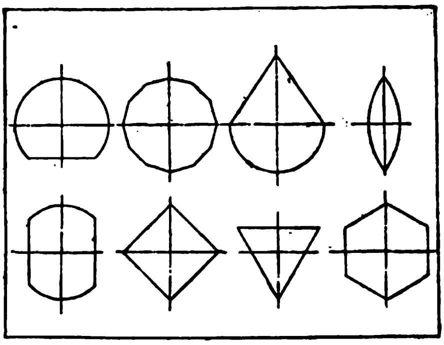


FIG. 431.

A DIE-FILING MACHINE.

The die-filing machine illustrated in Figs. 433, 434, and 435, while being designed particularly for die-making, is now in use in many of the best-equipped factories in this country at a variety of other work.

A great deal of metal pattern work may be done on this machine at a great saving of expense. Hardened dies, gauges, etc., may be lapped much faster and truer than by hand. A variety of small parts too delicate to be milled may be filed accurately and economically. It is also well adapted to making a great many templets and forming-tools.

In the following pages I illustrate a few ways in which the filing machine is adapted to die-making and in which it has proved itself a success by actual use in various tool-rooms where it has been installed.

In filing dies by hand as per Fig. 432 a man must work in a cramped position where the light is often very poor and where the lines to which he is working are generally on the side away from the source of light. He must watch the lines and keep his surface flat and true, while all the time exerting no small amount of strength.

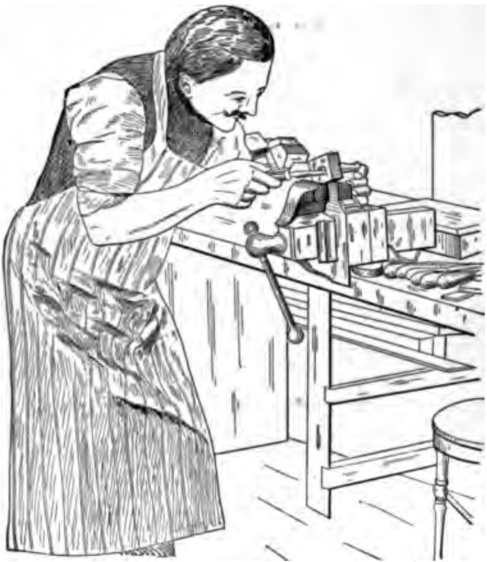


FIG. 432.

Under these conditions die-making requires a very high-priced man and he must spend a good part of the time in testing the accuracy of the work and in resting.

With the filing machine the work is flat on the table with the lines in plain view and where it will obtain the best possible light.

The correct amount of clearance or angle is accurately obtained, and the file moving in an absolutely straight line gives a true, flat surface with no rounded edges. Thus the operator, as shown in Fig. 435, is relieved of these details and may devote his attention solely to guiding the work.

The machine does the hard work, and the operator is in a comfortable position and able to do more and better work.

The cut Fig. 433 shows the machine sawing out a die. In a variety of dies the lines are straight or nearly so, and an ordinary 6-, 7- or 8-inch blade may be used, sawing very close to the lines, giving the proper shear by tilting the table, and leaving very little filing to be done.

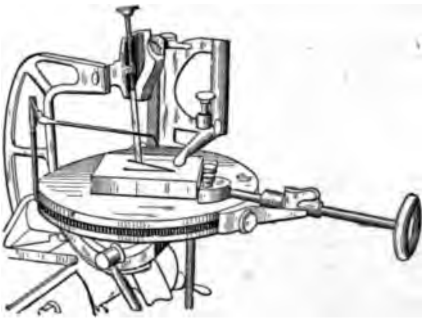


FIG. 433.

For smaller work a narrow blade may be used which may be turned in small circles; there can be had a 4-inch blade $\frac{3}{14}$-inch wide with wide kerf for this work.

In cut Fig. 434 is shown the manner of using large files for roughing. The file is clamped rigidly at both ends and the work held against it with the feed-screw and guided by hand.

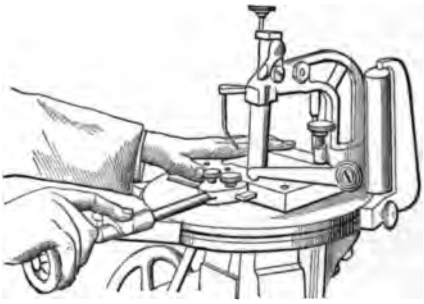


FIG. 434.

The file moving straight up and down gives no chance of rounded edges and the stock may be removed very fast.

Fig. 435 shows the method of finishing small work with small files. The file is held in the lower clamp only, the upper clamp removed, leaving the work free to be taken out and examined at will without disturbing the file. The file clamps are made to take any file from the smallest up to $\frac{1}{2}$-inch thick. Saws are instantly adjusted on pins on the file clamps.

File clears on the return stroke in either direction. Clearance is provided for the file whereby it is held clear from the work on the return stroke. The file may be made to cut on either the up or down stroke by changing the crank-pin to the opposite end of the crank-arm. The amount of clearance is adjustable from $\frac{1}{32}$ to 0 by means of a knurled-headed screw at the front of the frame.

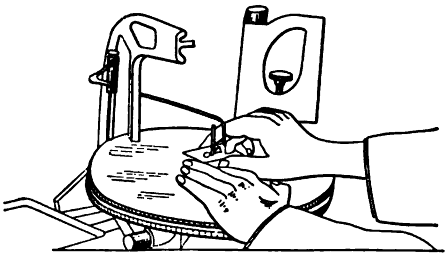


FIG. 435.

Tilting table. Graduated readings are provided by which the machine can be set at any angle with mechanical exactness. Files a straight and true surface.

Feeding. A screw feed, operated by hand, is provided, by which the work can be fed to the file in any direction on the table.

An adjustable strap is provided to hold the work down to the table. This is especially useful in sawing and heavy filing.

An air-pump is provided to blow away the chips and filings, by which the work and file are kept clean, insuring a smooth cut.

Four changes of speed are provided: from 60 to 450 revolutions.

CHAPTER XXIV.

The Art of Working Sheet Metals in Dies and Presses.

USE OF SHEET METAL IN PLACE OF OTHER MATERIALS.

THE marked progress that has been made in the art of sheet-metal working and that made in the use of the power-press for the cheap and accurate production of large and small, plain and ornamental sheet-metal parts, during the last decade, has led to the use of sheet metal as a material in the construction of many articles and appliances formerly made from other materials.

Dies, operated by presses—power, foot, hydraulic, and hand—do a stupendous share of the work of manufacturing metal goods, from the small trouser button to the massive boiler head. Not only are these tools used for the simpler operations required in the cutting out of irregular shapes cheaply and accurately, but for bending, twisting, drawing, embossing, and forging operations as well.

As an instance of what is being accomplished along the line of sheet-metal working in dies, I may state that in the sample room of the great press and die works of E. W. Bliss Company, of Brooklyn, N. Y., may be seen samples ranging all the way from an aluminum mandolin body to a full-size sheet-metal barrel, and from sheet-metal sinks and boiler heads to aluminum automobile bodies.

Next to a thorough understanding and appreciation of the power-press as a machine tool, a practical understanding of the most approved methods and processes for the economic production of sheet-metal parts and articles in it is most necessary to those engaged in the working of sheet metals. Although the number of establishments where sheet metal is worked in dies is great, there are many where the most approved processes are not known, or the proper construction of the tools is not understood. In such works the interdiction to the rapid and accurate production of new and unusual shaped articles lies in those responsible for results not being familiar with the construction and use of suitable tools.

SIMPLEST CLASS OF PRESS TOOLS.

The simplest class of tools used in the power press are those for ordinary bending. In this class of punches and dies it is necessary to combine simplicity with durability and cheapness; and one of the things to be prized is an ability to devise simple and effective means for producing in the fewest number of operations the articles required, and constructing the tools so as to allow of being set up and operated by unskilled help. Very often it is possible to design a die that will accomplish in one operation that which usually requires two or more to produce, being, of course, of a more complicated and accurate construction and requiring more skill and intelligence to operate. On the contrary, though, it is often preferable to increase the number of operations—by adopting simpler methods—in dies that will stand rough usage. The nature of the work and the quantity of parts required should determine this.

"GANG" AND "FOLLOW" DIES.

For the production of small sheet-metal articles which are required to be pierced, bent, formed or stamped at one or more points, the dies should be, whenever possible, of the "gang" or "follow" types; that is, tools in which gangs of punches and dies are assembled and located so that results desired in the finished blank will be accomplished progressively in one operation. It is only by the use of such dies that small sheet-metal articles can be produced in large quantities at a profit. All too frequently dies of the plain or "single" type are used, and three or more sets of them are required, when the same results could be accomplished in one operation if the proper attention were given to the devising of suitable tools. When sheet-metal articles are required in large quantities an operation saved means a great deal; and if two operations can be saved even at the outlay of considerable money and time, the results attained will more than compensate for all.

PIERCING OR PERFORATING DIES.

The construction of punches and dies for piercing or perforating sheet metal is comparatively simple and no very intricate methods are involved. Their construction is usually similar to that of the "gang" type, and they are used for operations on work ranging all the way from ornamental thin sheet-metal articles to the punching of holes in steel beams and boiler plates. The holes pierced may be of any shape and spaced as desired. Often a number of small blanks are produced at each stroke of the press by dies of this class; a sheet of metal of the required width being fed to the dies automatically. Perforated sheets of different metals are now in great demand and are used for a variety of purposes too numerous to mention.

PROCESSES FOR DRAWN WORK.

For the production of drawn and formed shells from sheet metal, the dies in general use consist of four distinct types. The first and most primitive method consists of punching out the blank to the desired shape and size in a plain blanking die, and the pushing it through the drawing die, or dies, according to the desired length of the shell. This manner of producing shells is the cheapest only where a small quantity is desired. The second method is by the use of compound dies and the double-acting press, in which the blanking punch descends and punches out the blank, and then remains stationary while the shell is being drawn and formed by the internal drawing punch. The third method is by means of a punch and die of the combination type, in which the punching and drawing dies are combined and are used in a single-acting press. This method is by far the most popular and generally used one, as well as the most practical for the production of plain or fancy drawn shells which are not required to exceed one inch in height. The design and method of constructing dies of the combination type differ according to conditions; but the fundamental principles involved are substantially the same in all of them, and may be adapted for the production of drawn shells of any shape which it is possible to produce in one operation in a single-acting press. The fourth and last method of drawing shells is by means of triple-acting drawing dies; they are used to produce shells which are required to be blanked, drawn, embossed, lettered, paneled, in one operation; and are used in triple-acting presses.

Farther on in this work all the different types of dies used for the production of drawn sheet-metal work are fully illustrated and the most approved methods of constructing them exhaustively described.

DEPTH WHICH MAY BE DRAWN IN SHEET METAL.

The depth which may be drawn in sheet metal in one operation is usually equal to about one-half the diameter for small cups, and one-third for large vessels.

Where a depth greater than can be drawn in one operation is required, it is necessary to accomplish the job in two or more operations; drawing a larger and shallower shape first, and afterward reducing the shell to the desired size and shape.

ANNEALING AND LUBRICATING IN DRAWING.

In deep drawn work the edge becomes irregular, and requires trimming before finishing the piece. It is also necessary in such work, or in other cases where the metal is severely worked, to anneal the metal during the processes; but tin-plate is ruined by annealing; hence such work is drawn and annealed before plating, or if some stiffness is required in the finished articles, one drawing operation may be performed after annealing and plating.

When drawing bright steel it is necessary to use oil as a lubricant, and apply it in spots over the sheets before they are worked up.. In working tin-plate the coating of tin, together with the thin film of oil left on it from tinning, are ordinarily sufficient lubricant; but in drawing large pieces in a double-acting press a stick of paraffin wax may be passed once around the edges of the blanks.

THE DRAWING AND FORMING OF DECORATED SHEET-METAL ARTICLES.

By far the greatest development in dies for the drawing of sheet metal has been along the line of decorated tin boxes. The fundamental practical points to be kept in mind when constructing dies for working such stock are as follows: Make three templets—one for the drawing die, another for the drawing punch, and a third for the corners, so as to get them the proper radius. Finish the drawing die, the punch plate, the two sides of the blank-holder ring and the inside of it, and the drawing die, before starting on the cutting die or punch. Then make your trial draws until the proper blank is found. When the exact blank has been found, finish the cutting die and the outside of the blank-holder ring, and fit the blanking punch. Take a cut off the die base after the die has been hardened—this base should be, of course, of mild steel. For decorated metal allow about .006-inch clearance in the drawing die; that is, finish the drawing die .006-inch and two thicknesses of metal larger than the drawing punch; while for plain tin allow about .0035-inch clearance in the drawing die. By giving this clearance there will be no necessity for easing up with files or scraping or grinding, and the designs on the metal will not be marred or scratched. Round the edges of the drawing die smoothly; if the draw is very short, $\frac{1}{32}$ inch will be enough, and if long, increase it accordingly. Be careful to get all the corners of the drawing punch the same radius and those in the die also (plus two thicknesses of metal and the clearance) and lap very smooth. By keeping the foregoing points in mind no trouble will be encountered when constructing a die of this type or in using it either.

"FINDING" THE BLANKS FROM WHICH TO DRAW SHELLS.

The finding of the proper size blank for drawn shells is usually a troublesome matter; however, the way to figure out the approximate size of a blank for a straight cylindrical shell is as follows: Take the outside diameter of the shell to be drawn and add to it the length or depth of same. Then add to this $\frac{1}{32}$ inch for every $\frac{3}{4}$ inch of depth, and the resulting total will be very near the exact size of the required blank. For deep shells this rule will allow of finding a blank which, when the shell is drawn, will leave enough for trimming; while for shallow depths, which will draw perfectly straight across the top, a slight reduction in size will be necessary. The amount to deduct will become apparent after the first trial draw.

There are any number of rules for figuring the side of blanks, in which the principle upon which the finding of the diameter is based is that the area of a drawn shell equals the area of the blank from which it is drawn. But as this is never the case, because of the fact that all metals stretch and run unevenly under drawing pressure, the rules work well only on paper. The way to construct a drawing die in the shortest possible time is to figure out the approximate size of the blank in the manner described in the foregoing; cut out and file up a templet according to the result; make the drawing portions of the die; make the trial draws; discover where there is an excess or a deficiency of metal; make a new templet, which should be almost perfect, draw it up, and if found correct finish the cutting portions of the die.

CHAPTER XXV.

The Making and Use of Punches and Dies for Sheet-Metal Working.

HAVING in the preceding chapter presented the fundamental principles and practical points which are necessary for the toolmaker to know in order to construct and use dies successfully, I will devote this chapter to describing and illustrating the various types of dies in general use. The designs have been selected as representing the most advanced practice in the best shops, and may be adopted, with slight modifications, in dies for the production of sheet-metal parts and articles in endless varieties.

The number of dies shown in this chapter and the one following is sufficiently large, and the variety representative enough, to allow of the reader comprehending all types. When, in the case of the descriptions, it has been found expeditious to describe means and ways for constructing, this has been done. In fact I have adopted this method all through the book; for I do not think it is enough merely to illustrate the tool; the mechanic is also interested in the manner in which it should be made and how the desired results may be accomplished.

THE MAKING AND USE OF SIMPLE DIES.

I will first show and describe a number of dies that are invaluable for use in the average machine-shop, especially the jobbing tool-shop. The dies shown are the most simple and inexpensive of their class for work of the kind shown. Fig. 436 is known best among die-makers as an emergency die—that is, a punch and die for producing a small number of blanks of a given shape and size, of which the blank *X* is an example.

The die *A* consists of a piece of $\frac{5}{16}$-inch flat tool steel, planed and fitted to the bolster, with the shape of the blank worked out at *B B*. In dies of this kind, when only a small quantity of blanks are to be punched, the clearance or taper of the die from the cutting-edge is considerable, as the more clearance given the less work and skill required to finish, allowing the blank just to fit at the cutting-edge. This die is hardened and drawn. For the punch a cast-iron holder *C* is turned and finished and faced flat and smooth on the front. The punch *D* consists simply of a piece of $\frac{1}{4}$-inch flat tool steel worked out and sheared through the die and left soft. It is then hard-soldered to the face of the holder *C*. For punching blanks from thin sheet metal to the number of 10,000, this die is all right. Although some may say "a botch job," the results will be found to be all that is required. This style of die is used universally in almost all of the fancy sheet-metal goods houses, as the number of different shapes, and the small quantities required, necessitate the elimination of all unnecessary expense.

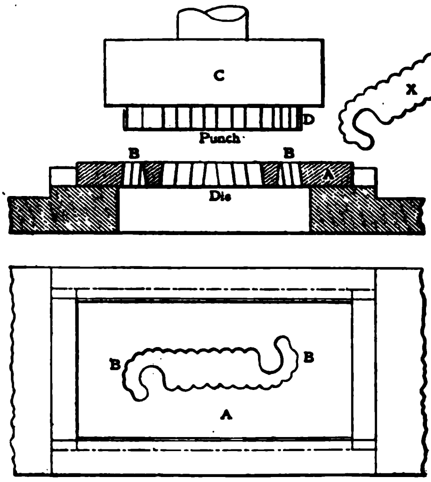


FIG. 436.

The die shown in Fig. 437 is known as a shearing or finishing die for heavy blanks and is used for finishing work such as is often done in the milling-machine, or grinder. The blank *Z*, as will be seen, is a small handle punched from $\frac{7}{32}$-inch mild steel. In punching for heavy blanks the punch is always fitted very loosely to the die, and the blank produced is generally concave at the edges, and has a ragged appearance where it has cut away from the rest of the stock. To remove these defects and marks, the blank is sheared through the finishing die, Fig. 437, when trimming or cutting off a shaving of stock all around, the blank leaves it smooth and has an appearance of having been milled. In making dies of this kind one of the blanks that have been punched is taken and filed and finished all around the edges, removing about .003-inch of stock all around. The blank is then used as a templet for finishing the die, letting it through from the back and filing the die straight, with just the slightest amount of clearance, being sure to have the blank a good fit at the cutting-edge. The inside of the die is then finished and polished as smooth as possible at *G* and then filed taper downward from *H*. *I* is the gauge plate which is worked out and finished to allow the rough blank to fit nicely within it. The plate is fastened to the face of the die by the screw *J* and the dowels *K*, so that the blank will rest on the face of the die *I* with an equal margin all around for trimming. Great care should be taken in adjusting this gauge plate to its proper position, as the small amount of stock to be trimmed will not allow much leeway. The die is

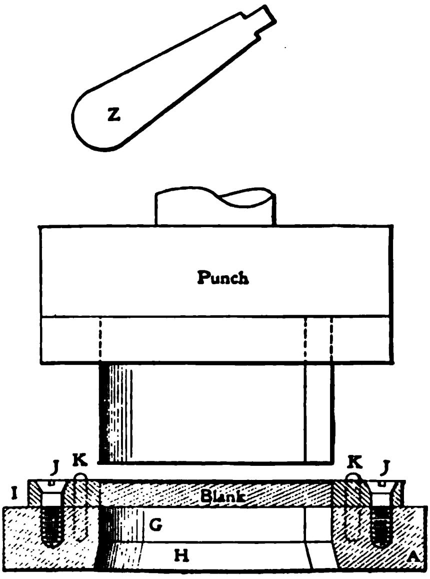


FIG. 437.

hardened and drawn to a light straw color and the face is ground and oil-stoned, leaving it as sharp as possible. The punch is constructed in the regular way and fastened within the pad, as shown. The punch is sheared through the die and left a snug fit within it, after which it is highly polished and finished and left soft. In use, the blank *Z* is placed within the gauge plate *I*, and, the punch descending, it is sheared into the die at *G*, trimming and finishing it all around, and, if the die has been polished, leaving a nice smooth finish, producing as good a job as could be done more expensively in a miller. A large number of different small pieces in demand in the average machine-shop, when the quantity permits, could be finished at a greatly reduced expense by this means.

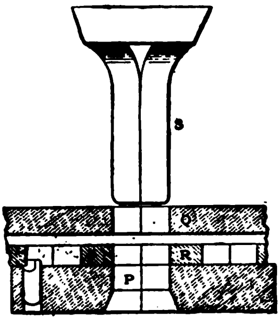


FIG. 438.

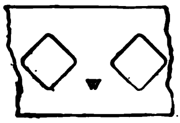


FIG. 439.

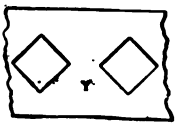


FIG. 440.

When a nice polish or finish is desired on the work the blank is forced through a second die, which is relatively the same as the one shown in Fig. 437, except that it tapers slightly from the cutting-edge, being about .002 inch smaller at the back than at the cutting-edge. This die is also highly polished and finished, and left very hard. By being forced through the die, the metal around the edge is slightly compressed, and polished by the friction. I have seen blanks treated in this manner that had all the appearance of having been polished or buffed. This die is known as a burnishing die, and is excellent for quick and cheap production.

The punch and die shown in Fig. 438, although of the simplest design, form a great tool for accomplishing by inexpensive means results that generally involve considerable time and cost. The die shown is for finishing square holes after the first operation, and *Y* the appearance after being finished. Of course they could be finished by broaching, but the punch shown is the better method. After the holes have been blanked they are ragged and uneven at the edges. They are also left undersize about .003 inch.

The punch *S* is first finished on the miller to a perfect square of the size required—that is, .003 larger than the blanked hole. After being polished, the face is finished dead square and the edges are left sharp. The punch is then hardened and slightly drawn. The die *P* is then made and worked out until the point of the punch can be entered, and then, using it as a broach, forcing it into and through the die, leaving it an exact duplicate of its shape. The die is then filed taper from the back, leaving it straight about $\frac{5}{32}$ inch from the face, as shown at *P*. After the holes for the dowel and stripper screws are let in, the die is polished, hardened, and drawn slightly. The edges of the end of the punch *S* are then ground and rounded, so as to enter the hole in the stock easily. The stripper *Q* consists of a piece of $\frac{1}{4}$-inch flat machine steel with a channel milled down through the centre, in depth and width sufficient to allow the strip of steel within which the holes are punched to pass through it freely without side play. A small pin projecting above the face of the die *P* at the left side acts as a gauge for locating the holes true with the die. The punch and the die being set up, the strip is inserted within the gauge or stripper plate *Q* with the first hole under the punch. The punch, descending and entering the hole, gradually compresses the metal and finishes it, leaving a dead square hole with a nice smooth finish on all sides. The punch shown should enter the work for a full inch of its length. This style of die can be used for finishing a large variety of different shaped holes in heavy iron or mild steel, where they are all required to be of the same size and shape; also leaving a finish that it would be impractical to accomplish by other means.

PUNCHING BRASS CLOCK GEARS—MOVABLE STRIPPING DEVICES.

The gear shown in Fig. 441 was produced complete from ⅛-inch-thick sheet brass. Holes were required to be punched at *A*, *B* and *C*, five sections *D* cut away, the centre hole punched, and the teeth cut. The gear was required to be perfectly true with the centre hole and to balance evenly.

A cross-section of the punch and die is shown in Fig. 442, with a plan of the die in Fig. 443. Three successive operations produce the gear. The three holes *A*, *B* and *C* and the large centre hole are pierced in the dies at the first stroke, the sections *D* are punched out at the second, and at the third stroke a finished gear is cut out. Hardened and ground bushings are used for the dies *h*, *d* and *m* to allow of easy repairing.

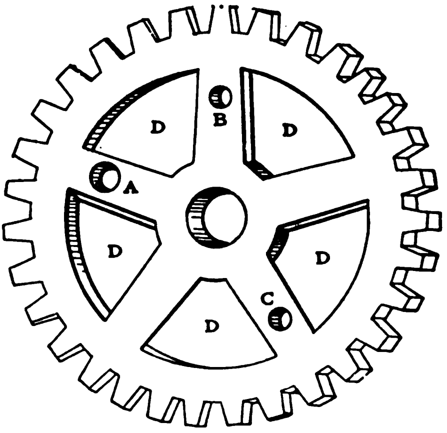


FIG. 441.

It is in the die *X X* that unusual conditions are met. This die, used for punching the sections *D*, is made in two parts, although this might not appear necessary to some. The work to be done, however, in this die was of such a character that satisfactory results would have been impossible with a solid die.

The "spider" used in this die is shown as located and fastened in position in Fig. 443, and in detail in Fig. 444. As shown, there are five arms *Z* and a hole at *Y*. The outside of the wings are turned taper, large at the back and smaller at the cutting face. The spider was left large all over and hardened and drawn to a light straw. It was then chucked and the hole *Y* was lapped

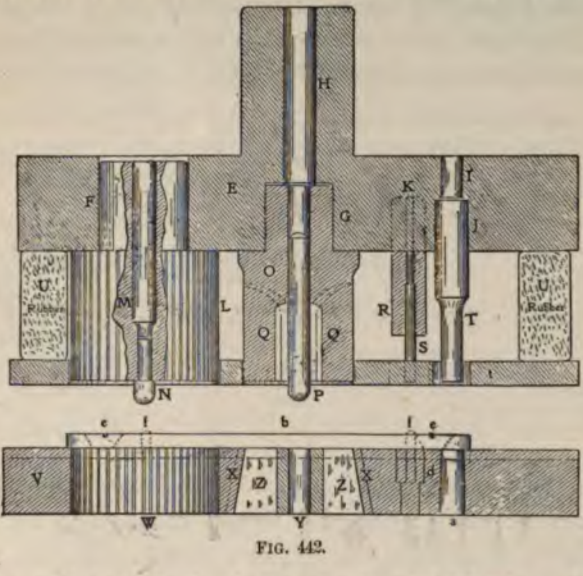


FIG. 442.

to the size of the hole in the gear, after which the spider was forced on a mandrel and ground all over to size, which was, to

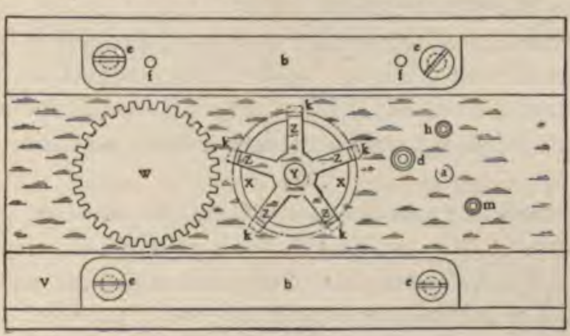


FIG. 443.

say the least, a very nice job. The portion *X X* in the die plate was bored taper, and five shallow channels *K* were cut into its walls, as locating seats for the wings *Z* of the spider.

The blanking die *W*, in which the gear teeth are cut and the finished piece is produced, was finished by reversing the usual

method; that is, instead of shearing the punch through the die the die was broached by the punch. As will be seen in Fig. 442, this punch is finished with a stem *F* to fit a hole in the machine-steel holder *E* and has a hole straight through it for the pilot pin *N*. The teeth in the punch were milled and finished in the same manner as a gear would be, getting as smooth a finish as possible. The punch was hardened and drawn slightly, after which the face was ground and stoned keen. The die *W* was then finished by using the punch as a broach. The die plate *V* was hardened and ground. Then the punch *L* was re-annealed and sheared into and through the die. Thus a perfect fit was attained. The punch was left soft.

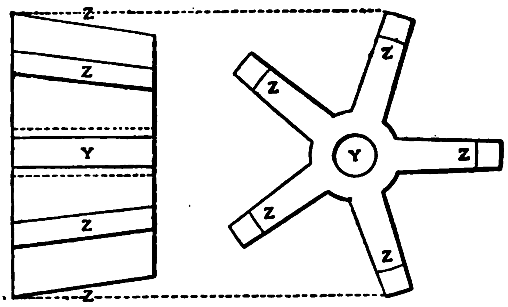


FIG. 444.

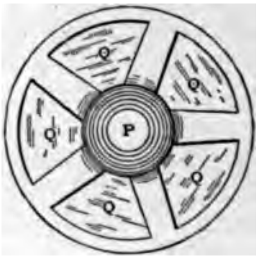


FIG. 445.

The centre piercing punch *T* is in one piece and is let into a counterbored seat *J* in the holder. The other three piercing punches for the holes *A*, *B* and *C*, Fig. 441, are of drill rod, and are located in strong supplementary holders, as shown at *R*, *S* and *K*.

The punch (or punches) for cutting the sections *D* in Fig. 441 is shown at *Q Q* in Fig. 442, and a plan or face view of it in Fig. 445. *P* is the pilot pin. The punches *Q* form parts of the solid piece *O* and were not hardened; as if they had been the resulting distortion would have made a fit within the die *X X* and the spider *Z* impossible. As it was, by shearing the sections *Q* into the die and leaving them soft, no difficulty was experienced getting a close fit at all points.

The only part requiring further description is the stripper, which is of unusual construction. As shown in Fig. 442 it is located on the punch, or "male" die. It comprises a flat mild-steel plate *T*, fitting around the punches proper, two blocks of hard-spring rubber *U U*, one located between the stripping-plate and the punch-holder face at each end, and four studs of the usual construction, not shown. One of these studs is located at each of the four corners, with the heads let into counterbored holes in the back of the holder and the ends screwed into the stripping-plate. No other springs were required, as the rubber blocks answered for that purpose.

SPRING STRIPPERS.

Although a great many die-makers claim that spring strippers located on the punch should not be used where a stationary stripper can be located on a die, still there is a large variety of work for the production of which a movable stripper must be used if accurate results are to be obtained.

It is well known that punching or perforating dies having stationary strippers will distort the plates or articles punched by them, and often to such an extent as to require subsequent straightening. Thus, where accurate parts, such as are used for clocks, electric instruments, etc., are produced in gang dies, the distortion of the metal as it is worked upon by the various punches, will, when stationary strippers are used, prevent the production of satisfactory work. On the other hand, where movable strippers (any of the various types I mean, and not merely the one shown here) are used, a clear space is left between the punches and dies, enabling the operator to manipulate and observe his work quickly and accurately. The stripper comes down on the strip first, straightening and clamping it before the punches enter, while the pilot pins locate the various operations positively. The metal is held under pressure while the punching and stripping are being done, and by this means the work comes out perfectly straight and true. Where a number of small perforating punches are required, they may be made, with the use of the movable stripper, much shorter than a stationary stripper would permit. At the same time a smaller hole, in proportion to the thickness of the stock, may be pierced because of the close support which the movable stripper (when well fitted) gives to the punches up to the point where they enter the stock.

PUNCH AND DIE FOR END FINISHING, CUTTING OFF AND BENDING SHEET METAL FROM THE STRIP WITHOUT WASTE.

Up at the left in Fig. 446 is shown, somewhat enlarged, the piece made by the punch and die (Figs. 446 and 447). These articles are manufactured by the million and are used as protective seals for wooden boxes and cases, their use preventing the usual loss from theft while cases of goods are in transit. They were produced in one operation, without waste, from $\frac{1}{32}$-inch-thick cold-rolled stock of the required width; and the efficiency

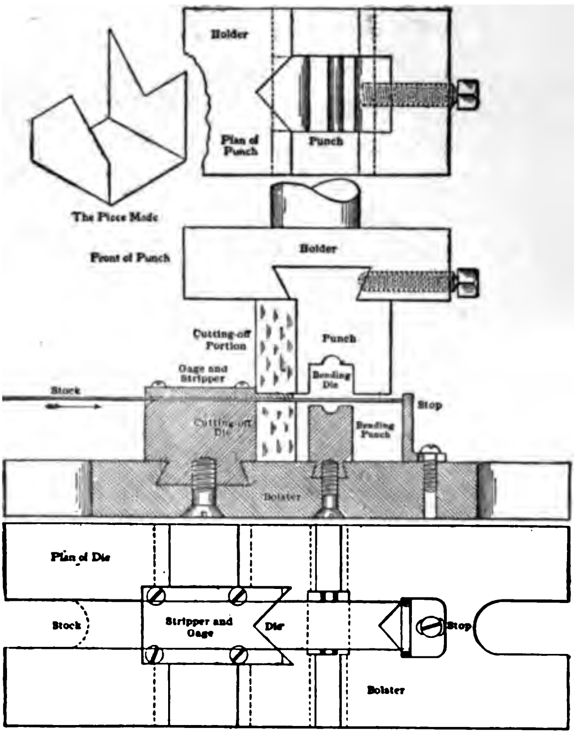


FIG. 446.

of the die can be appreciated from the fact that it produced 215,000 of the articles shown without grinding.

Fig. 446 is a plan of the punch, a side view of both punch and die, and a plan of the die without the stripping arrangements; while Fig. 447 is an end view of the tools, with the stripper and the inclined fork for operating it in position. The punch consists of the usual cast-iron holder and tool-steel punch. The punch is finished at one end to act as the cutting-off and end-finishing punch, and in the centre as the bending die, the half-circular groove in the top being let in for the clearance for the stripper pin (see Fig. 447). The punch is hardened and drawn to a dark straw temper.

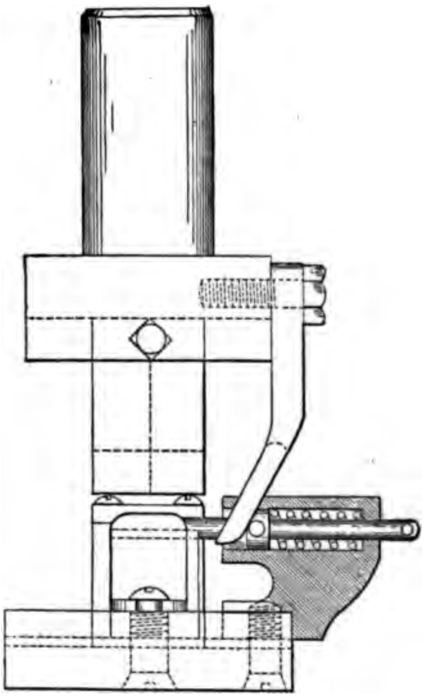


FIG. 447.

The die consists of a flat cast-iron bolster into which the cutting-off and end-finishing die and the bending punch are located in dovetailed channels and fastened by flat-head screws let in from the bottom of the bolster. The adjustable stop plate also is fastened to the bolster. The stripper and gauge combined consists of a piece of $\frac{1}{4}$-inch stock with a channel cut down through one side wide enough to allow the stock to be fed through it easily, but without side play. It is fastened to the face of the cutting-off die by four round-head screws, as shown in the plan. As shown in the section of the die, the bending punch has a half-round groove let into the face to correspond with the other half in the bending-die portion of the cutting-off punch. The cutting-off die and the bending punch are hardened and drawn to a light straw, after which the sides of the bending punch are eased off a bit toward the bottom, so that the metal, when bent, will cling to it instead of to the bending portion of the cutting-off punch.

The stripping arrangements, as shown in Fig. 447, consists of the following parts: The stripper proper is a round stud let into a small casting located in the dovetailed channel for the bending punch in the bolster. This stud has a pin let through the back end to prevent it from springing out too far, when the punch is up, by the action of the spring at the back. A stronger pin is let through the enlarged portion or collar of the stud, so that the inclined fork, which is fastened to the back of the punch-holder, will, while descending, move the stripping-stud back and off the face of the bending punch.

When the die is in use, a strip of metal is entered beneath the gauge plate and is allowed to project a slight distance beyond the

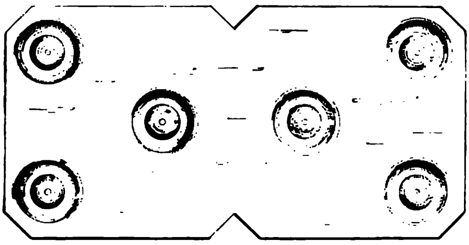


FIG. 448.

cutting die. The press is stepped and the end of the stock is trimmed and finished to the shape shown in the plan of the die. The stock is then moved forward against the stop, and, as the punch descends, the piece is cut off and bent over the bending punch, the cutting punch descending about $\frac{3}{8}$ inch below the cutting-edge of the die. As the punch ascends, the inclined fork releases the stripping-stud which springs outward and throws the finished piece off the bending punch and into a box at the front of the press. The parts are thus produced without waste and as rapidly as the stock can be fed. At first strips of metal were used in the die, but after a short time rolls of the required width with 200 feet of stock in each were used. They were placed on a reel at the left of the press and the stock was fed automatically, through a pair of straightening rolls.

TWO DIES FOR METAL BOX-CORNER FASTENERS.

The article shown in Fig. 448 is a sheet-metal trunk corner. These corners are made flat, and are intended to be bent at right angles after one end is nailed on to the trunk. The notches on the sides serve as guides for nailing the corner in the proper position, and they also facilitate the bending. The corner is so made that the edges bind the wood closely when nailed on, thus making a very rigid corner.

Two operations are necessary. The first, that of notching and cutting off the blanks, is done by the punch and die shown in Fig. 449, showing a section of the punch and die and a plan of the die. There are three punches fastened in a machine-steel pad, which is in turn fastened to the face of the holder by six flat-head screws. The end-notching and cutting-off punch is at the right, and is about $\frac{3}{32}$ inch shorter than the centre notching punch at the left. This is so that the centre notching will have been accomplished before the blank is cut off.

The die is made in the regular way, with two short gauge plates at the right end, and with the stripper extending entirely across the face of the die. When the blank is cut off it drops off at the back, as the press is inclined and there is no gauge plate to hinder it.

For the finishing operation—that of drawing and forming the six raised spots and perforating them in the centre—the punch and die, Fig. 450, are used. The punch is in a dovetailed channel in the holder and fastened to the bolster by two flat

screws let in through the bottom. The dies proper are six tool-steel bushings, finished on the face with a forming tool to the shape required, and a small hole let down through the centre. They are hardened and forced into counterbored holes in the die plate. The die plate is beveled at the edges to correspond with the punch at *F F*. The die plate is left soft and the punch is hardened. The drawing-punch sections are at *E E E E*, and are finished as shown in the face of the punch. The gauges for locating the work upon the die are three in number, and are located as shown at *G G G*. The press in which the tools are used is inclined and the blank is placed on the die with two sides against the gauges *G G G*. After the punch has descended and returned, the finished work remains sticking to the die, from which it is thrown off by the operator by his en-

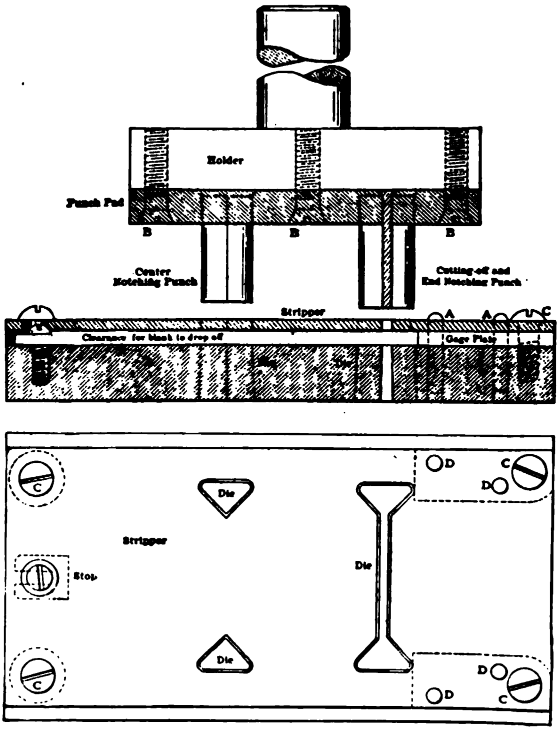


FIG. 449.

tering a thin fork under the front right-hand end and snapping the piece off.

Both the dies shown and described herein were used in a sheet-metal establishment in which rapid and economic production is absolutely necessary in order for their products to sell at a profit.

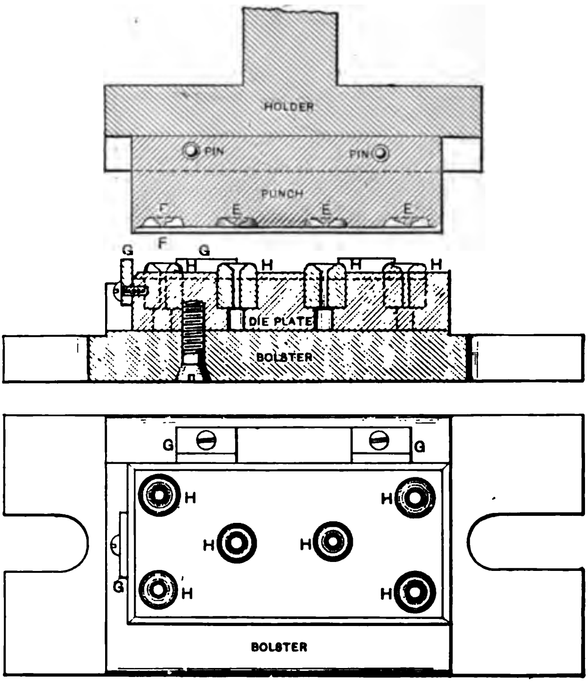


FIG. 450.

PIERCING AND SPREADING DIE FOR BOX STRAPS.

At Fig. 451 is the outline of a portion of sheet-metal box strap used for binding the edges of wooden boxes. These straps are produced in coils of from 5,000 to 6,000 feet, with slots pierced 2½ inches apart along the entire length. These slots are first punched and then spread to make openings for the nails. The spreading of the slots makes the opening large enough for

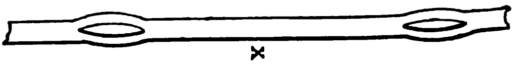


FIG. 451.

the nails and does away with the liability of the strap breaking out at the eyes when the nails are driven into the wood. The material is $\frac{3}{16}$ inch wide and 0.032 inch thick.

The punch and die used to produce these straps are shown in Figs. 452, 453, with a plan view of the punch above in Fig. 452.

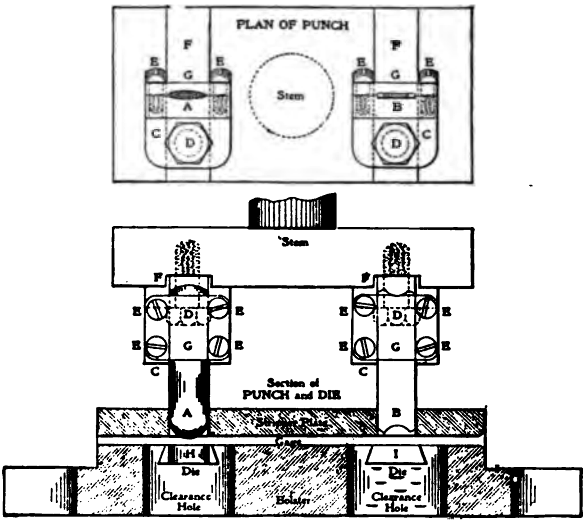


FIG. 452.

These tools show how very frail punches may be used. The capacity of this die is 30,000 feet of stock a day, fed automatically.

The punch consists of the stem of cast iron; the two punch-holders *C C* of machine steel; the clamping plates *G G* of the same; the piercing punch *B* and the spreading punch *A*; eight screws for fastening the clamping plates and two cap screws for fastening the holders to the stem. The punch-holders are located in square milled channels *F F* in the face of the stem, and are fastened in position by the screws *D*. The punches are of uniform section and double ended, and are located in seats in the holders and clamping plates. The faces are sheared so that two points will enter the stock first and thus the holes will be pierced progressively. The spreading punch *A* is bevelled and rounded at the face, so as to spread the stock gradually. These punches are hardened in oil between flat plates and are drawn to a blue. They last a very long time, as they can be used from either end and ground until only a short section remains in the holder. By shearing the cutting faces of the piercing punch the clamping lid *G* holds it tightly; it is surprising how easily the stock is pierced.

The construction of the die is of a rather novel character, and after numerous experiments it was found to be the best. It consists of the usual cast-iron bolster, with two dovetailed channels let into the face for the dies, the dies *H H* and *I I*, screws for locating, adjusting, and fastening them, the stripper and gauges, which are combined in one plate, and the screws and dowels for locating and fastening it to the face of the bolster.

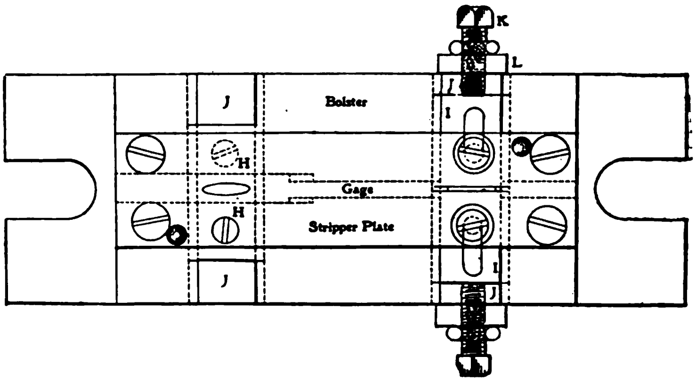


FIG. 453.

The piercing dies fit tightly in the dovetailed channel at the right. They have slots as clearance for the fastening screws and to allow of adjustment. Pieces of $\frac{5}{16}$-inch flat steel at each end of the channel serve as brackets for the adjusting set-screws *K K*. This way of making the piercing die allows of the faces being ground when dull with very little trouble, and insures its long life. The spreading die is in one piece and is fastened and located within the channel *J* by the two flat-head screws. In the true sense of the word it is not a die, but instead a support for the spreading punch *A*. The stripper and gauges, in one piece, are machined from a piece of $\frac{5}{8}$-inch-thick machine steel, with a narrow channel milled down along one side as a gauge for the stock, and widened at the left-hand end as clearance for the stock after the pierced hole has been spread. The hole in the stripper for the punches is a tight fit, this being necessary because of the frailness of the punches; the stripper is heavy for the same reason, as, in order to accomplish good results and to insure the longevity of the punches, they must never entirely leave the stripper.

When in use the metal is fed from a reel at the right and wound up again on a reel at the left, the press running continuously for two hours without any attendance. There is a large variety of pierced work which could be produced at the minimum of cost by dies of this construction.

AN IMPROVED PIERCING DIE.

Fig. 454 shows an improved piercing die, used in the same establishments for piercing holes in 100-foot lengths of flat cold-rolled stock, $\frac{7}{8}$ inch wide by $\frac{1}{16}$ inch thick, feeding the stock automatically as described for the first die. The holes pierced were No. 24 gauge, $5\frac{1}{2}$ inches apart.

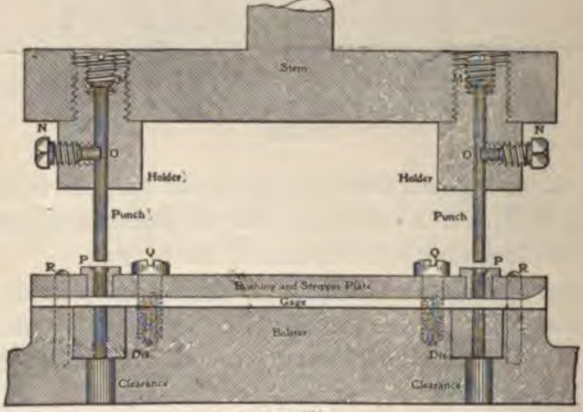


FIG. 454.

The punch pad has holes bored and threaded for the two punch-holders. These holders are turned from $1\frac{1}{4}$-inch round stock, with holes for the Stub-steel punches. They are flat milled on two sides for a wrench. The backs of the punches are enlarged and tapped for the adjusting or butt screws *M M*. When the punches became short through grinding, a piece of the same stock is placed between them and the faces of the butt screws. The punches are fastened by the set screws *N N* and the semi-circular faced plugs *O O*, thus doing away with the notching or flattening of one side of the punches and allowing of using them for a greater portion of their length.

The die is composed of the bolster, the two piercing dies, lapped and ground to size and forced into counterbored holes in the face of the bolster; the stripping plate and gauges, all in one; the two punch bushings *P P* lapped to a tight fit for the punches, and the screws *Q Q* and dowels *R R* for fastening and locating the stripper plate to the face of the bolster, as shown.

GANG DIE FOR BOX-LID FASTENING PLATES.

The engraving (Fig. 455) shows a fastening plate used for hasps for fruit crates and box lids, and Figs. 456, 457 show the punch and die for its production. The article has three holes pierced in it, a portion of the centre drawn and formed, and the ends trimmed to a curve. The stock used was cold-rolled sheet metal, and the punch and die were of the "gang" type.

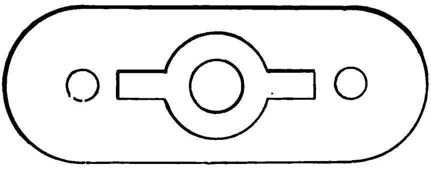


FIG. 455.

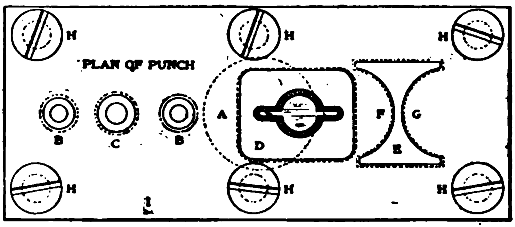


FIG. 456.

In the punch *A* is the stem or bolster, *I* the punch pad, *B B* the two small piercing punches, *C* the large piercing punch, *D* the drawing and forming punch, *E* the trimming and cutting-off punch, which trims and cuts off at *F* and *G* respectively, and *H* the six flat-head screws for fastening the punch pad to the holder.

In the die *J J* are the small piercing dies, *K* the large one, *L* the drawing and forming die, *M* and *N* the cutting off and trimming die, and the remaining parts the stripper and gauge plate. The die plate was hardened and drawn to a light straw. The punches, except the forming and drawing punch, were hardened and drawn to a dark blue, the drawing punch was hardened and drawn from the back, getting the back soft and leaving the drawing face very hard.

The stock is fed to the die from left to right automatically, the holes being pierced first, then the formed and raised portion drawn, and, lastly, the finished plate cut off and the front end of the next piece trimmed. The drawing punch is left the shortest; this being done so that the piercing punches will have pierced the stock and the finished piece have been cut off before the raised portion of the next piece is produced; thus there is no shifting of the metal while the different operations are being accomplished. The metal used for the fasteners came in rolls of the required width. It is straightened somewhat by the rollers of the automatic feed and flattened by the flat portion of the drawing punch.

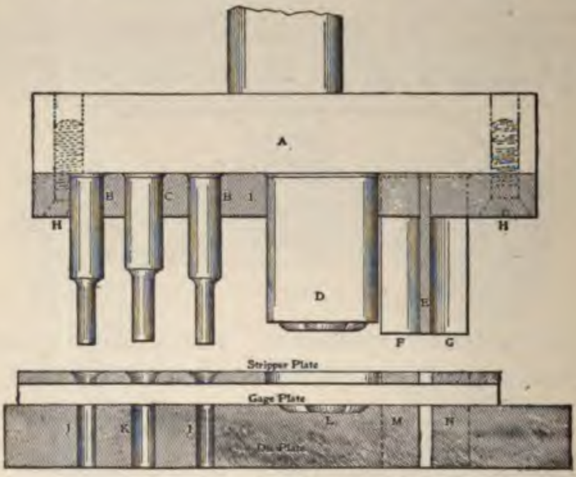


FIG. 457.

LARGE DRAWING DIES FOR CIRCULAR SHELLS.

The Figs. 458 and 459 show a collection of large drawing and re-drawing dies for producing from flat blanks large circular shells. These dies were made in the works of the E. W. Bliss Company, and formed part of an order of presses and dies for a sheet-metal-goods concern in Europe. They were made to metrical dimensions, the diameters ranging from 290 to 600 millimetres or, say, from 11.4 to 23.6 inches, the largest set at the left and the smallest at the right. Each set consists of a drawing punch, a drawing die, and a blank-holder. Drawing dies of this type differ from those used for small work in that they draw the articles from blanks previously cut, instead of being provided with cutting-edges which punch the blank at the same stroke. The outer edges of the drawing dies are turned to the same diameter as the blank to be drawn, and the operator locates the blank by simply laying it on the face of the die and locating the edges with his fingers. Very often, however, shells of different heights are produced in the one die. This of course requires blanks of different sizes and gauge plates to locate them true on the die. Dies of this type are made to produce large shells of any style or shape, and draw the article at one or more operations, according to the shape and depth to be obtained. In work of considerable taper, such as large flared pans of thin stock, two or more blanks may be drawn at the same stroke of the press.

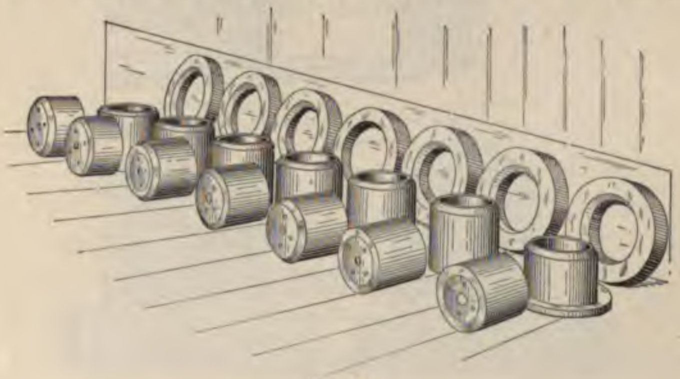


FIG. 458.

Fig. 458 shows seven sets of drawing dies with inside blank-holders. As shown here, they are used for re-drawing shells which have been first drawn in dies having outside blank-holders, like the dies shown in Fig. 459. The inside blank-holder holds the partly finished articles at its lower bevelled edges between the bevelled edge of the punch and the bevelled seat in the die, while the punch draws it into a deeper shape of reduced diameter.

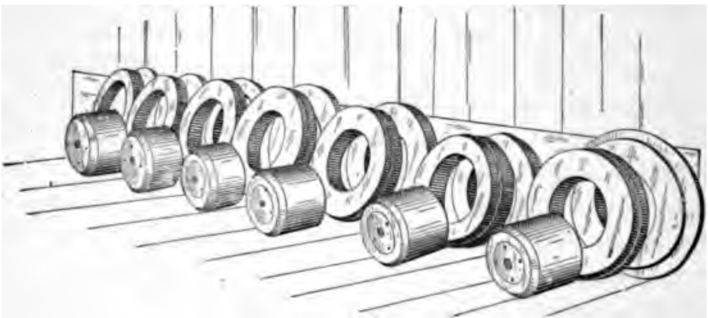


FIG. 459.

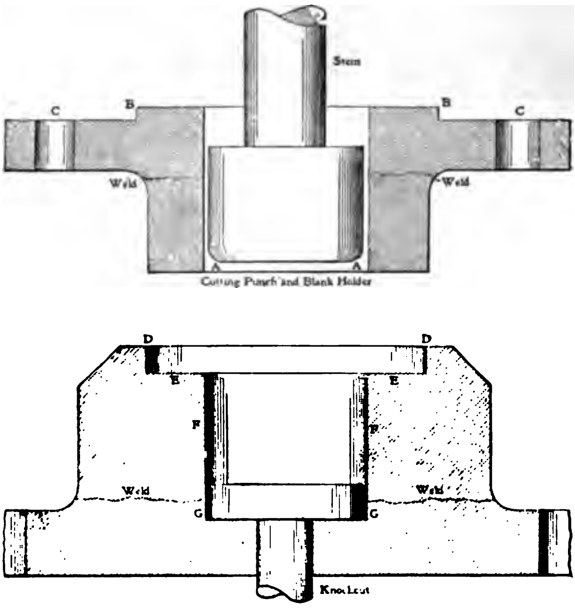


FIG. 460.

These drawing and re-drawing dies are mostly made of a special grade of cast iron, treated in such a manner as to give a very dense and uniform texture to the metal at the working surfaces. To do very accurate work, however, steel rings are set into the dies, and the blank-holders are made of steel castings, which adds considerably to the durability of the tools. For shells which have to be finished to very accurate diameters hard steel "sizing" punches and dies should be used after the last re-drawing operation.

THE DRAWING OF DEEP SHELLS FROM SHEET METAL.

The manufacture of deep sheet-metal shells, of small diameter, has progressed constantly, and to-day results are attained which a few years ago were only thought of as remote possibilities.

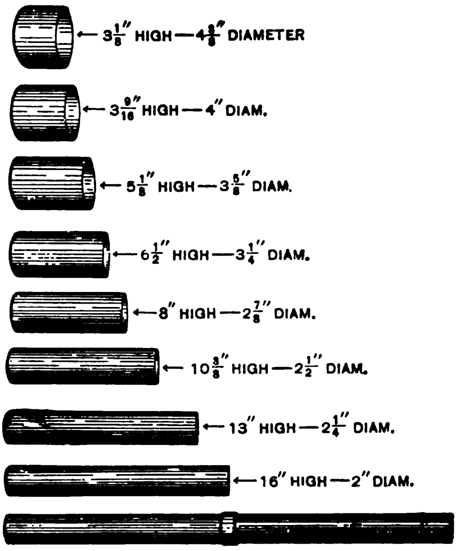


FIG. 461.

The operation of drawing sheet-metal shells has really changed but little; the same means, with slight modifications, being used at the present time for the production of deep shells of small diameters which formerly were thought practical only for producing shells of shallow depths and large diameters. The presses, in which drawing dies are used, have been built larger and stronger, and with a greatly increased length of stroke, while the dies have been simply modified for a wider range of work.

As an illustration of what is being accomplished in the drawing of sheet metal we show in Fig. 461 the successive results of the eight operations required to draw a shell copper $\frac{1}{16}$ inch thick, 16 inches deep by 2 inches in diameter. Two of the shells are assembled and shown at the bottom. They are used as parts of a patented mineral-water cooling apparatus.

The blank required for this shell was 8 inches in diameter, and the thickness of the stock decreased from $\frac{1}{16}$ at the start to $\frac{1}{32}$ at the finish. The die used for the cutting and first drawing operation is shown in Fig. 460, and is of the double-acting type. In the punch the cutting and blank-holder part is a forging of wrought iron with a tool-steel ring welded on as shown for the cutting portion. The projection *B* is for locating it true on the outer slide of the press. *A* [illegible] awing punch, the stem of

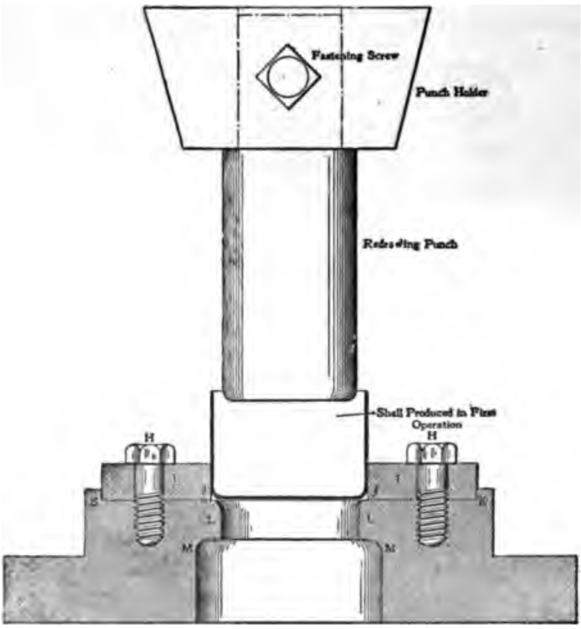
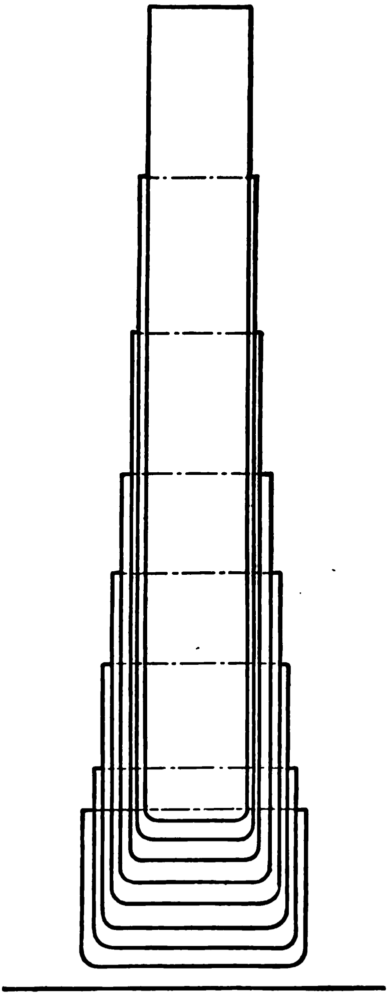


FIG. 462.

which is reduced as shown to fit the inner slide or ram of the press.

In the die, *D* is the cutting-edge, where the blank is cut; *E* the face upon which it is held by the punch while being drawn, *F* the drawing die, and *G* the knock-out pad. This die is set up in the press and the metal is fed to it and blanked and drawn to the shape shown in the first operation in Fig. 465. The press has a toggle movement which insures a more perfect "dwell" of the blank-holder slide than could be maintained in a cam drawing press, and effects a large saving in friction and power. The adjustment of the drawing-punch plunger is effected by means of a double-ratchet device, which is handy and quick of operation.



Blank, 8 inches diameter.

FIG. 463.

For the seven re-drawing operations in the production of the shells, dies of the type shown in Fig. 462 were used. These dies were of the push-through type and were used without the usual inside blank-holders, as the small difference in the diameter of the redrawn shells did not require it. Instead of the shell being pushed completely through these dies, they were fed to the top of the die by an automatic knock-out on the press in which they were used.

By noting the difference in the diameters of the re-drawing-operations, Fig. 463, the manner in which a shell of small diameter and great height may be drawn and the number of operations required will be understood. The lubricant used in the re-drawing operation was lard oil, and there was a decided polish on all the shells produced. The dies used for the re-drawing operations were made from a special grade of chilled iron, while the punches were of tool steel. Both punch and die for each operation were highly polished. The die and punch used for the sizing or finishing operation were of tool steel, and were hardened, ground, and lapped to the required size. As will be seen, the drawing of deep tubes of small diameters is not such a difficult accomplishment as some people imagine; all that is necessary being the adoption of proper dies, their accurate construction, and their use in presses which have been built specially for such work. When the difference in the diameters of the re-drawing operations exceeds ½ inch, inside blank-holders must be used. For certain metals inside blank-holders, in the re-drawing dies, will allow of the desired results being accomplished in three or four operations (through the perfect holding of the metal while drawing or re-drawing), which would require six, seven, or more operations were dies adopted in which inside blank-holders were not used.

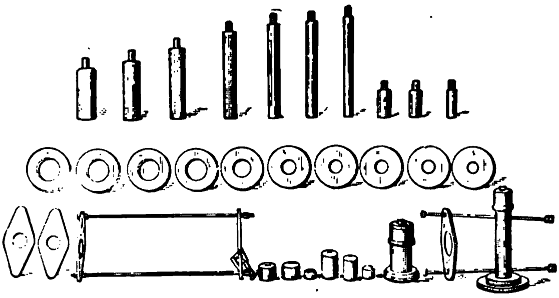


FIG. 464.

Fig. 464 shows the tools used. The punches are reduced at the end and threaded to screw into the holder in the press ram. The dies are shown beneath and punches, and the locating seats in each are shown plainly. The devices shown at the bottom comprise the knock-outs and other tools.

HOLLOW CUTTERS FOR PUNCHING LEATHER, CLOTH, AND PAPER.

When work is to be punched from leather, cloth, or paper, hollow cutters or "dinking dies," will be found to give better satisfaction than the punch and die of the usual construction, as they are cheaper to make, and there is practically no limit to the number of pieces that can be cut at one stroke of the die, which may be operated in the ordinary press, or by hand with the use of the mallet.

The die is made from stock rolled specially for this class of work, and is usually composed of Swedish iron, laid up with a good grade of tool steel, as shown in cross-section in Fig. 465, the steel being laid on the straight side of the bar, and a 20-degree bevel edge given to what is to be the outside of the die. A templet is made of sheet metal of the exact shape of the work wanted, and this is used by the smith in welding up the blanks.

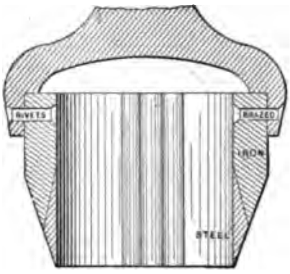


FIG. 465.

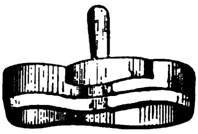


FIG. 466 a.

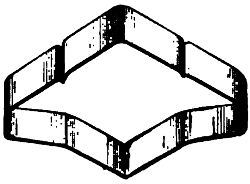


FIG. 466 b.

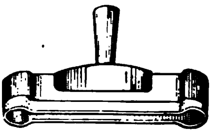


FIG. 467.

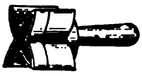


FIG. 468.

The accuracy with which forging is done with these dies is remarkable, a variation of $\frac{1}{100}$ inch from the pattern being the exception rather than the rule. The cutter, after being welded, is taken to the vise and worked out on the inside with the file to the exact shape of the templet; allowance having been made on it for the slight amount of shrinkage caused by the hardening. The die is then finished on the outside by grinding.

When the tool is to be used in a press a handle will not be necessary; intended to be used by hand, a handle is secured to the upper part of the die. This handle is forged with a projecting lip shutting over on the outside of the cutter, the weight of the blow being taken by this shoulder which bears directly on the upper part of the cutter. This is secured in place by rivets, and is then taken to the fire and brazed in the usual manner, using borax as a flux and soft brass solder for the brazing. This operation is generally done after the die is ground, and before it is tempered.

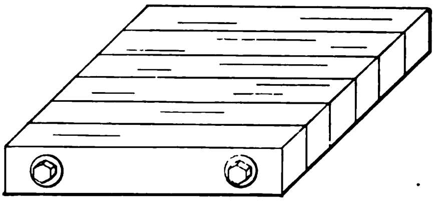


FIG. 469.

Sometimes the die is used in an inverted position, being laid on the press with the cutting-edge up, the work being placed on the same, and as the gate of the press descends the material is forced through the die. When this method is practised, the die should be brazed to a foundation plate, in order that it may be properly secured to the press. The handle or this foundation plate may be removed, and the die may be repaired or worked over into other shapes if required.

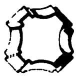


FIG. 470.

For a surface to be used for the cutting-edge of the die to strike upon, there is nothing better than a built-up block of hard, seasoned rock maple, set endwise of the grain. This is made by sawing up a plank into pieces about 4 or 6 inches long, gluing them up into a block, and then securing it by bolt passing through the whole, as shown in Fig. 469. This will be found to give better results, with less wear, if kept damp; that is, a wet cloth should be laid on the block when the same is left at night.

The group of cutters shown in Figs. 465–470 illustrate several of the many styles of "dinking dies" which are in general use.

CHAPTER XXVI.

The Making and Use of Punches and Dies for Sheet-Metal Working.—*Continued.*

A PUNCHING AND CURLING JOB.

IN Fig. 471 are shown the results of successive operations in the production of a sheet-metal part of unusual shape which formed part of a patented apparatus.

The upper diagram in Fig. 471 shows the results of the first and second operations. The holes in the ends were punched, the ends were shaped, cutting off the piece, and twenty-nine slots along one side were punched.

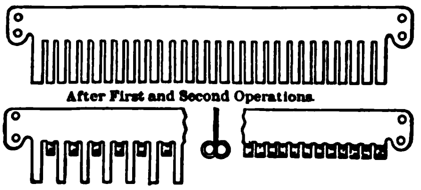


FIG. 471.

The piercing of the holes, shaping the ends, and cutting off the pieces were done in the first operation by the punch and die shown in Fig. 472. The work in this operation is all at the ends, necessitating a punch and die of different construction from those usually used. In the die section the die for piercing and that for cutting off and end-shaping are dovetailed into the face of the cast-iron bolster, one at each end, and secured by taper dowel-pins. The gauge-plate extends along the entire length of the bolster, and is fastened to the die faces with the stripper plates by flat-head screws. The stripper plates are made of extra heavy stock and are worked out so that the punches are supported while doing their work. In the punch section the construction is similar to that followed in the die section, in that the cutting-off and end-finishing punch is dovetailed into the holder and located by means of a taper dowel; while the piercing punches are let into a pad, dovetailed into the holder, and located in the same manner as the cutting-off punch. The piercing punches were made of drill rod, hardened, tempered, and of a length sufficient to allow of their always being in the stripper, thus obviating the tendency to bend or snap off. The stock, which required no side trimming, was fed across the die faces automatically. The four holes were pierced at the left, and then the last end of the piece and the first end of the next piece shaped, and the piece was cut off by the large punch at the right.

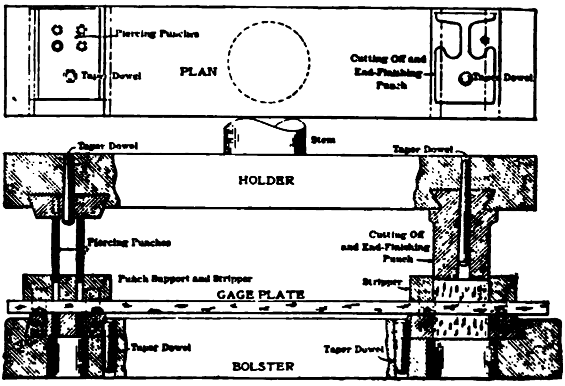


FIG. 472.

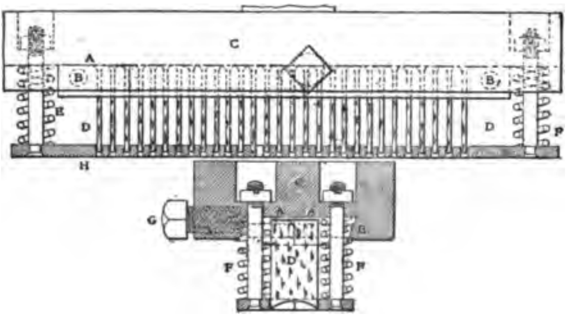


FIG. 473.

For the second operation, that of piercing the twenty-nine slots, a punch and die of intricate and accurate construction were required. In Fig. 473 are shown a front elevation partly in section, and a vertical cross section, respectively. I illustrate only the punch, as the die was almost identical in construction. The punch section consists of, first, a cast-iron holder *C*, then a supplementary punch-holder *A*, the latter in two sections, the twenty-nine punches *D*, and a spring-actuated stripper *H*. The spring stripper is left off the plan so that the construction of the other parts may be more clearly understood. The manner in which the punches are located and fastened is unusual. First two pieces *A* of ½-inch-thick annealed tool steel were planed to butt together sidewise and then dovetailed into *C*. These two sections were then clamped together, and twenty-nine slots were milled into them, in depth equal to half the width of the piercing punches. The manner in which the punches were let into these slots and upset at the back, the two sections strengthened by dowels *B B*, and then driven into the dovetailed channel in the holder, will be understood, as well as that the milling of the slots in the sections *A A* of the pad was an accurate job. It was accomplished by careful work on the universal milller. The slots were milled about .002 inch smaller than the thickness of the punches. The making of the twenty-nine punches was also a job requiring skill and care. The punches were left over size all over, then hardened between oiled plates and drawn to a dark straw to within ½-inch of the backs, and from there on to a dark blue to allow of upsetting them within the pads at the backs. They were then ground on all sides to size.

The spring stripper plate *H H* was worked out to fit around the punches rather snugly, so as to give them as much support as possible up to the point where they entered the stock. The faces of the punches were sheared so as to commence to cut at both edges before the centre of the stock was cut away. This is shown in the end view at *I*.

The die was made in the same way as the pad *A A*, being in two sections, which were located together by dowels, and were dovetailed into a bolster of the usual kind. Considerable care was required in the hardening of the die section, and in the grinding of the faces afterwards, in order to insure the alignment between the twenty-nine piercing dies and the punches; and although the man who hardened them understood his business and turned out a good job, it was necessary to peen the edges of some of the pad slots so as to crowd a few of the punches over a thousandth of an inch or so. It was not found necessary to grind all of the dies, although about every third one had to be touched up on the sides with a fine wheel, taking care just to touch the tight spots.

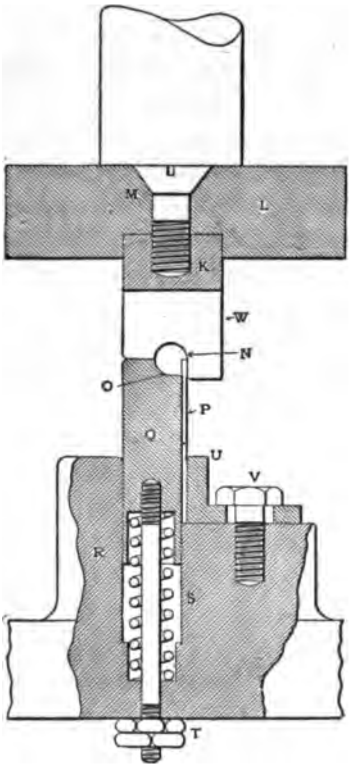


FIG. 474.

When using the punch and die a blank was located against stops on the face of the die and the press was "stepped." As the punch descended the spring stripper plate *H H* flattened the stock and held it securely in position while the slots were being punched. As the punch rose, the stripper forced the work from the punches and allowed it to drop off the die face. After the punch and die had been in use a short time it was found necessary to re-grind the die faces, as some of them had sheared. Then the punches were entered into the dies and solder was run around them at the pad faces. This rendered the alignment perfect, and we had no more trouble.

It will be seen in Fig. 471 that the sections left between the slots punched in the second operation have to be curled alternately, half of them one way and the other half the other way. It was at first thought that a die of considerable intricacy would be necessary; but it was at last decided to do the curling in two operations—but with one die, and that a quite simple one.

I show in Fig. 474 a vertical cross-section of the curling die. *L* is the punch-holder; *K* the curling punch, located in a square channel in the holder face and fastened by three flat-head screws;

N N are the portions that do the curling, while the cutaway sections *E* are clearance channels for the sections of the stock which have to be curled in the opposite direction. *P* is the work, *Q* a spring supporting pad with the face worked out at *O* to the radius of the curl; *U* is a gauge-plate for locating the work against the pad *Q*; *R* is the bolster; *S* the channel in which the spring supporting pad moves, and *T* one of three spring studs.

The work is placed between the gauge *U* and the pad *Q* and against a gauge at the end. As the punch descends, half of the sections to be curled, or every other one, enter the curling grooves *N*, while the others enter the clearance channels *W*. The punch continues to descend and the metal follows around the curling grooves until the curls are completed, the pad *Q* descending with the punch. As the punch rises, the pad *Q* rises also and carries the work out of the locating slot between the pad and the gauge, and as the punch rises higher it leaves the work free on the top of the pad *Q* from which it is removed by hand. The fourth operation, curling the remaining sections in the opposite direction, is accomplished in precisely the same manner.

DIES FOR SHEET-METAL BAG-CLASPS.

In Fig. 475 are shown three views of a patented sheet-metal bag-clasp which was produced entirely by the use of dies, there being no hand work, except in feeding. The dies here shown are the most interesting ones of the set employed.

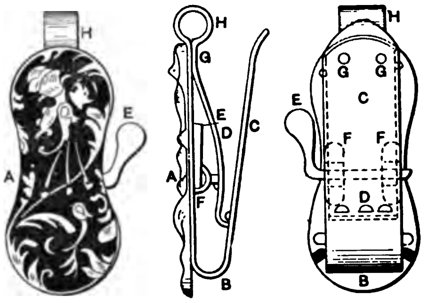


FIG. 475.

The clasp consists of eight parts: the embossed front *A*, a thin tin pad *B* fitting into the embossed part at the back, the hook or clasp part *C*, the spring *D*, the lever *E*, the two straps *F* in which it is located, and two rivets *G* for fastening the spring *D* to the hook *C*.

The first part produced was the embossed front *A*. This was struck up and drawn from very thin, soft sheet-brass blanks, which had been previously cut, the result being shown in Fig. 476. The second operation on the embossed piece was punching out the drawn and embossed portion from the rest of the blank, leaving the scrap as at Fig. 477. The piece produced has four small wings, which are afterward bent upward in a simple die in the foot-press and then bent inward, enclosing the pad within the embossed part. The die for the trimming and blanking operation is shown in Fig. 478. The punch has a spring stripper, while the face of the die is open and clear; thus the locating of the work is rapid, the work being pushed through the die and the spring stripper stripping the scrap from the punch when it slides off, the press being tilted.

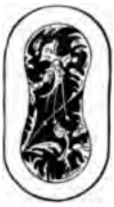


FIG. 476.

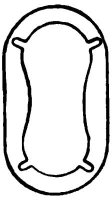


FIG. 477.

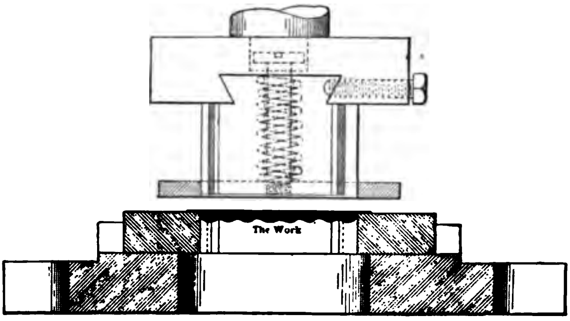


FIG. 478.

In Fig. 479 we have the punch and die used to produce the pad shown at the top of the cut. The work consists of cutting and bending up the four wings *G* and punching out the blank to the shape shown. The tools used for producing this part were of the combination blanking, piercing, and bending type, completing the work at one stroke of the press. In the die *N* is the bolster, *O* the blanking die, *Q* the piercing and bending punch pad, *R R* two of the piercing and bending punches, *P* the spring stripper in the die, *S* the spring, *T T* the two gauge-plates between which the stock is fed, and *U* the stripper for the stock. In the punch *H* is the holder, *J* the blanking-punch, *K K* two of the piercing and bending dies, *I* the punch pad, and *L* the punch

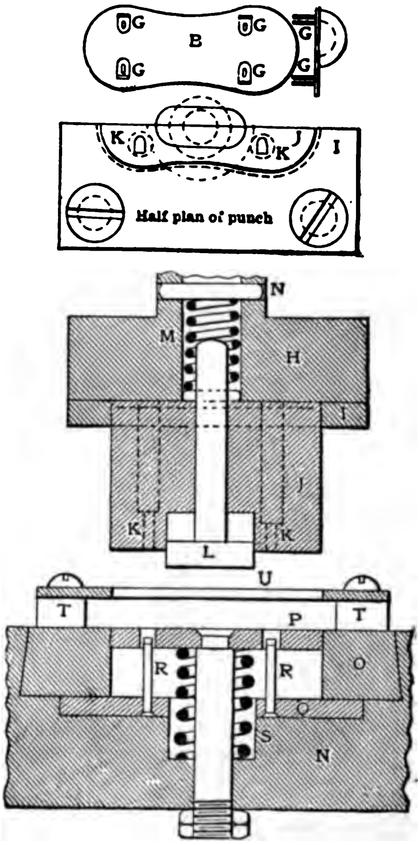


FIG. 479.

stripper. The press was tilted backward, the stock was fed from front to back, and the finished piece, after being stripped from the punch, dropped off into a box.

In Fig. 480 we have the clamp portion before the bending operation. In the production of this part four operations were

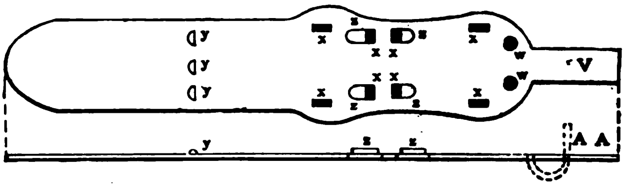
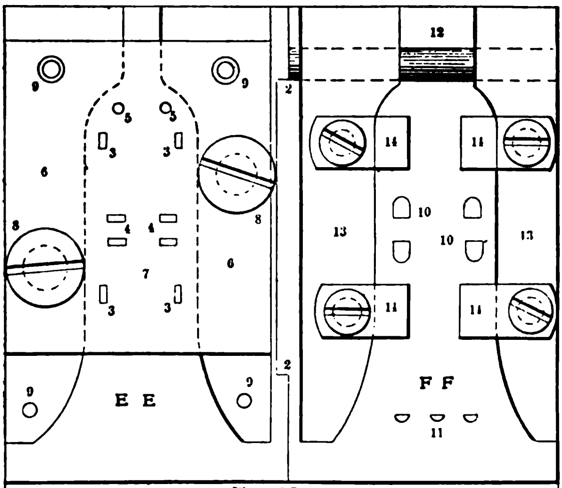
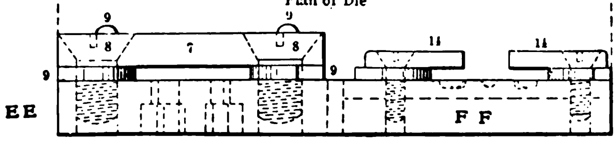


FIG. 480.

necessary. The first was the punching out of the plain blank. This was done in a simple blanking die. The second and third



Plan of Die



Front of Die.

FIG. 481.

operations were both done in one combination die. The tools are shown in Figs. 481, 482, and 483. The work to be done by these tools is the piercing of the eight slots X, Fig. 480, the piercing of the two holes W, the drawing of four shallow seats for locating the straps shown at F in Fig. 475, the throwing up of three small projections Y, and, lastly, the bending of part V to the shape shown by the dotted lines in the edge view, Fig. 480.

In the dies, Fig. 481, $E\ E$ is the section where all the piercing is done, and $F\ F$ the section where the forming, drawing, and bending are done. As shown, the two sections are locked together at 2 2. The bolster used with the dies is not shown. However, the dies were located in a channel and held and fastened in position by set-screws at each end of the channel. In die $E\ E$, where the piercing is done, 5, 3 and 4 are the piercing dies, 6 6 the two gauges which locate the blank for piercing, and 7 the stripper. The gauge-plates and stripper are located and fastened by the dowel-pins 9 and the two flat-head screws 8. In the section $F\ F$, where the drawing, forming, and bending are done, 10 10 are the seat drawing dies, 11 is where the small projections are formed, and 12 where the neck V of the work is bent; 13 13 are the two gauge-plates between which the work is located, while 14 are the stripping edges.

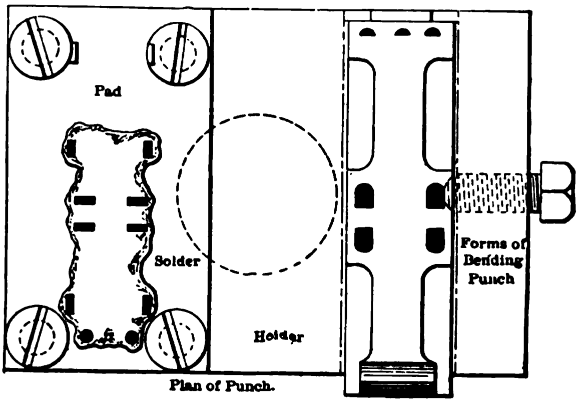


FIG. 482.

The punch-holder, Figs. 482 and 483, is of the usual construction, while the method of locating and fastening the punches is somewhat different from that usually followed. The drawing, forming, and bending punches are all contained in one steel block, which is worked out on the face to match the dies in *F F*. This block is dovetailed into the holder, and is then fastened and located in alignment with the dies by the set-screws shown at the side.

The section of the punch-holder devoted to the piercing operation is built in the usual manner; that is, a machine-steel pad,

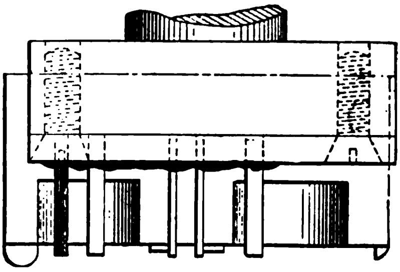


FIG. 483.

in which all of the piercing punches are located, is fastened to the face of the holder at this side by four flat-head screws.

The piercing punches were rather slender and frail, and it was necessary to be very careful in locating them in the pad. This was accurately accomplished by working out the pad and the piercing dies at the same time. Then the punches were finished to fit the dies, hardened and drawn, and then forced into the pad, upset at the back, and hard solder run around them at the face of the pad. As the holes for them in the stripper were made good fits, and as the stripper was of considerable thickness, all danger of bending, twisting, or breaking was obviated, as the punches never left the stripper.

The dies *E E* and *F F* were hardened and drawn a very little. The punch block, in which the drawing, forming, and bending dies were contained, was hardened on the face and left hard. All of the slot-piercing punches were hardened between oiled plates, while the two-hole piercing punches were hardened in oil.

Referring to Fig. 475 we have the flat spring part *D* of the clasp to complete the article. It is necessary to round off one end of this, punch teeth in the other end, punch two small holes, throw up a small lug, and bend and form the metal to a given shape. All of the work on this spring was done in the follow-die shown in Fig. 484. The stock, coming to the proper width, was fed between the gauge-plates on the die and against the stop-pin by an automatic roll feed, and then, the punch descending, the holes were pierced and the front end was trimmed.

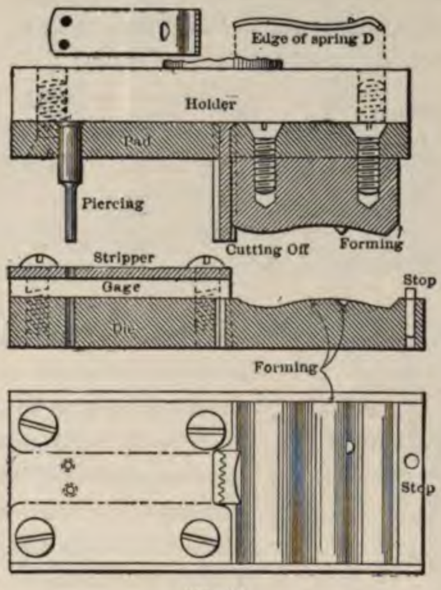


FIG. 484.

At the next stroke the teeth were punched in, the piece was cut off, bent, and formed, and projection was thrown up, the front end of the next piece was trimmed and the two holes were pierced. This die was an exceptionally rapid producer, an inclined press being used and the finished parts falling off at the back.

For producing the straps in which the lever worked a die which produced three at once was used for blanking, while the bending was done in a simple little push-through die in the foot-press. The lever was cast. In assembling the various parts to form the complete article shown in Fig. 475 a few foot-press dies of very simple construction were used.

A TRIPLE-ACTION DIE FOR BLANKING, DRAWING, AND EMBOSSING AN ALUMINUM SHELL AT ONE OPERATION.

As as instance of what is being accomplished at one operation in the line of embossed shells, I show in Fig. 485 two views of a shell which formed the cover of a box for a toilet preparation, and for which an order for almost one million was secured. The material used was sheet aluminum of a special alloy, and the result in the finished shell was very pretty.

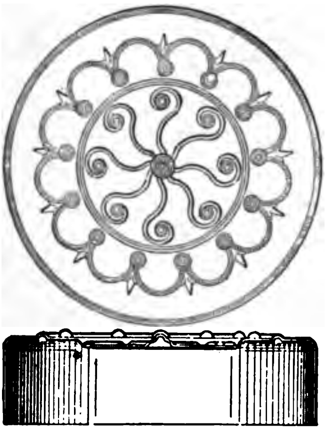


FIG. 485.

A triple-action "Bliss" cutting, drawing, and embossing press and a triple-action die were used. The chief advantage to be gained by the use of triple-action dies lies in the fact that the finished work from them is delivered *below* the die instead of at the top, thus enabling the operator to feed the metal continuously, instead of waiting for each piece to come to the top of the die and be removed or slid off before the next can be cut.

Fig. 486 is a vertical section of the lower or die portion, showing the die parts in position on the press bolster and the lower plunger. Fig. 487 is the upper or punch portion. In Fig. 486 *A* is the press bolster, *B* the raised or bridge bolster on which the cutting and drawing die *J* is fastened, and *D* the lower plunger with the embossing die *M*.

The cutting and drawing die *J* is in one piece. It was a forging of mild-steel base and a tool-steel face for the cutting and drawing portions. *F* is the cutting-edge, sheared as shown at *G*; *H* the surface on which the blank is held while being drawn; *I* the drawing-die portion, and *X* the stripping edge. The die is fastened to the face of the bridge bolster by the cap-screw *K*. *L* is a clearance hole in the bridge bolster. The embossing die is secured to the face of the lower plunger by the two screws *O*. *N* shows the embossing face of the die.

In the upper part of the punch part, Fig. 487, *Q* is the combined drawing and embossing punch, and *P* the cutting punch and blank-holder, which locates on the face of the outer ram of the triple-action press at *S* and is fastened to it by the cap-screws through *T*. The combined cutting punch and blank-holder was a forging of mild-steel back and tool-steel face, while the drawing and embossing punch was drawn and worked out of a round length of annealed tool steel. It is secured in the inner ram by a key through the taper slot.

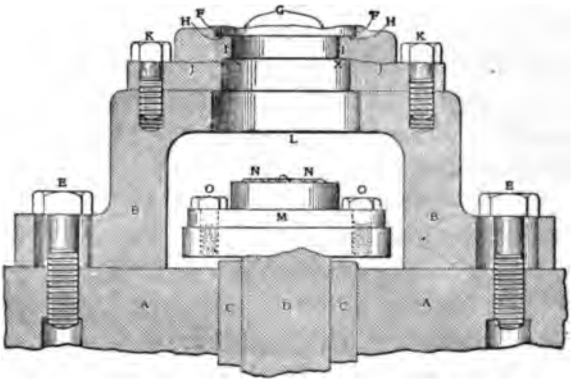


FIG. 486.

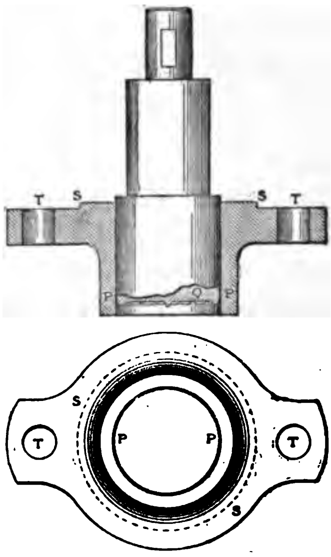


FIG. 487.

It will be understood that very accurate work was necessary in making the tools and that all working parts were hardened, drawn, ground, and lapped to a dead finish in order to have the work come out as required.

The manner in which the tools were used to produce the shell was as follows:

The lower die being fastened to the face of the plunger *D* and the upper die with the bridge bolster to the face of the press bolster, the combined cutting punch and blank-holder *P* is located on the face of the outer ram and the combined drawing and embossing punch in the inner ram. The strokes of the two upper rams of the press are then adjusted, and the lower one on which the embossing die is located is adjusted to almost meet the face of the embossing punch *Q* on its up-stroke. All is then ready. The combined cutting punch and blank-holder *P* is worked downward by the outer ram of the press, and travels slightly in advance of the drawing and embossing punch *Q* which is actuated by the inner slide, the outer slide of the press being so adjusted that after its stroke has been made it stops during about one-quarter of the rotation of the crank-shaft. The blank is cut out from the sheet and held between the annular pressure surfaces, *H* of the die and *P* of the punch, during the down "dwell" of the outer slide. Now, while the blank is held under pressure—which has been regulated to suit the special requirements of the metal to be drawn—the drawing and embossing punch *Q* continues to descend, draws the metal from between the blank-holding surfaces, and draws it into and through the die at *I*, the drawing and embossing punch continuing to descend until the shell has been drawn completely through the drawing die, carrying it down until its lower surface meets the face *N* of the embossing die—which corresponds in its function to the solid bottom in double-action dies—mounted on plunger *D* working in sleeve *C* on its up-stroke. It is actuated by arrangements at the side of the press, motion being communicated through cams on the end of the crank-shaft. Here the shell receives on its face the impression of the design shown in Fig. 485. On the up-stroke the finished article is stripped from the punch *Q* by the stripping edge *X*, and, the press being inclined, the work slides off at the back.

It is surprising how much fine work can be got out of a triple-action die in a day of ten hours, and it would pay any manufacturer who has work of the kind shown here to do in large quantities, to adopt dies of this construction, as any of his double-action presses can be arranged for them at a small cost compared with the increased output.

In regard to the making of the dies, I might state that they are easier to construct than those of the single-action combination type which are most frequently used for such work. There are fewer parts to the triple-action dies than to the others, and there is less liability of their getting out of order, while the hardening of the working parts can be done with the assurance of success, and the grinding and lapping of the hardened parts to the finish sizes afterward can be done with ease. In order not to leave any marks on the outside of the shell when drawing aluminum, it will be found well to lap the drawing die after grinding with a lap actuated in the direction of the working movement.

I neglected to state that it was necessary to lubricate the aluminum sheets before working, but as the cleaning of the covers afterward would have cost more than the making of them, and as the preparation which was to fill the boxes was such as to require the entire elimination of oil on the metal, we had to be very careful in lubricating the sheets so as to get a sufficiently thin coating on them to allow of its being taken up in the working of the metal. This was successfully accomplished by coating one sheet thickly with melted Russian tallow and running it through a pair of rolls, after which a number of other sheets were run through and coated evenly and thinly. The oil disappeared entirely during the blanking and drawing of the shell.

The cover was $3\frac{1}{4}$ inches in diameter, 1 inch high; was punched from stock slightly over $\frac{1}{32}$ inch thick and required a blank $4\frac{25}{32}$ inches in diameter, which left just the narrowest possible margin for trimming.

BLANKING AND DRAWING AN ALUMINUM SHELL.

Not very long ago I had a set of dies to make for the production of an aluminum box, and as it was necessary to construct the tools so that the articles might be produced at the minimum of cost, I adopted dies which would allow of producing a cover and a box complete at each stroke of the press; that is, one die for the cover and another for the body of the box. These dies were of the combination cutting and drawing type, in which the blank is first cut and then held between the annular pressure surfaces of the punch and blank-holder ring while it is being drawn up into the punch. The shell as drawn to form the body of the box, and the die used for it are shown in Fig. 488.

As I have been in a number of shops where they use two dies to accomplish results which are attained in this one, and as the construction and action of these dies are by no means well known, a short description of it may be of interest.

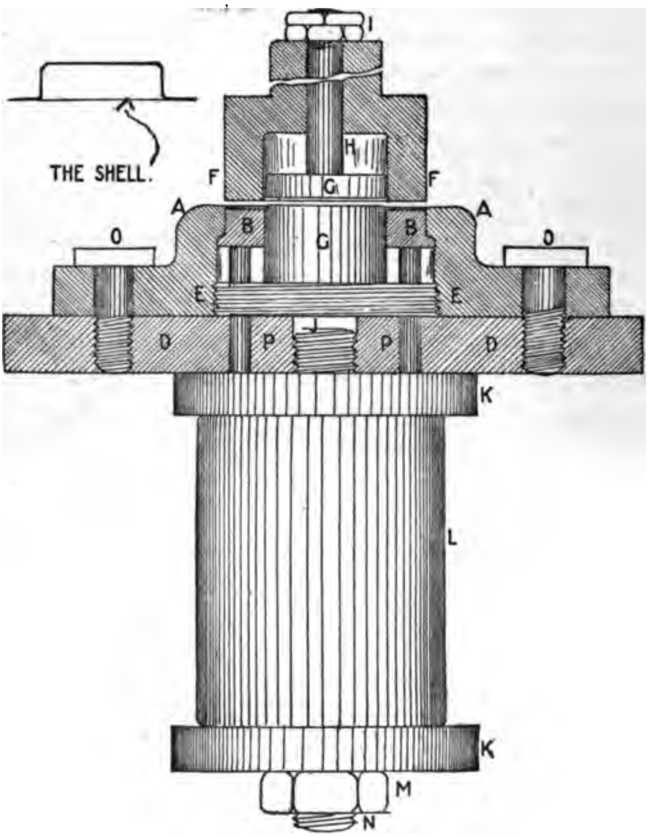


FIG. 488.

Fig. 488 shows a longitudinal cross-section of the die complete as it appears when set in the press and ready for work. *A A* is the cutting-die, a forging of mild steel with a tool-steel face to act as the cutting-edge; *G* is the drawing punch, which is located in the cutting-die by being screwed into a set at *E E*; *D* is the spring-pressure attachment plate, to which the cutting die is bolted by bolts *O O*; *P P* are two of the six tension pins which support the blank-holder ring *B B* and communicate the tension from the rubber spring barrel *L*. The spring-barrel attachment consists of the stud *N* which is screwed into a tapped hole *J* in the plate *D D*, the two cast-iron washers *K K*, and the rubber spring barrel *L*. This rubber spring barrel is usually about 3½ inches in diameter and 6 inches long, for drawing all shells up to one inch in depth. *M* is the nut for adjusting the pressure in the blank while it is being drawn up into the punch.

In the punch or upper section of the die, *F F* is the combined cutting punch and drawing die. It is a forging of mild steel with a tool-steel ring welded on to act as the cutting and drawing face. *H* is the drawing-die portion of this punch, *G* the spring pad which expels the shell after it is drawn, and *I* the adjusting nut for the spring pads. In a die of this kind the cutting punch, drawing pad, blank-holder ring, and cutting die are all hardened and tempered, the cutting-edges being drawn to a dark straw and the drawing portions to a light straw temper.

In using a punch and die of this kind the die is first set up on the press bolster and the plate *D D* bolted to same. The punch is then located in the ram of the press and aligned with the die. After this the stroke of the press is set so that the punch will descend the proper distance, the pressure of the spring buffer is regulated, and we are ready to proceed. A sheet of stock is entered to rest on top of the cutting-die and the press stopped. As the press descends, the cutting-edges punch the blank into the cutting die *A A*, where it is held between the faces of the punch and the blank-holder ring *B B*, and as the punch continues to descend the drawing punch *G* draws the metal up into the cutting punch and from between the pressure surfaces, the metal being held tight enough to prevent inceptive wrinkles and crimps from forming. As the punch rises the sheet of stock is stripped from it by bent pins placed around the cutting-die, and the finished shell is expelled from the inside by the spring pad *O* being actuated by a knock-out in the press body. When a die of this kind is used to an inclined press the finished shell falls off through gravity at the back.

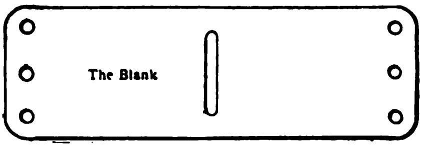
Combination cutting and drawing dies of the construction shown and described here may be used to the best advantage for the production of shells from stock as thin as paper up to $\frac{1}{8}$ inch thick. They may be used in either single-acting foot or power presses. In most cases the shells produced in dies of this kind are of shallow shapes, their edges frequently not being over $\frac{1}{32}$ inch deep, as for instance, can tops and bottoms, pail, bucket and cup bottoms, etc. On the other hand, however, dies of this class can be used for the production of much deeper articles, such as boxes and covers for blacking, lard, salve, and other goods up to $\frac{3}{4}$ inch deep, or for cutting and drawing burner and gas-fixture parts, toys, etc., up to 1 inch in depth. However, the best results will be secured in the drawing of shells which will not exceed $\frac{3}{4}$ inch in length, as in order to draw that depth the rubber spring barrel has to compress to its maximum, and to compress it more would cause the metal either to stretch exceedingly or to split. When it is desired to draw shells over $\frac{3}{4}$ inch in depth it will be found better to use two dies, a combination die and a re-drawing or finishing "push-through" die.

As the die shown here was for cutting and drawing aluminum, it may be well to assure my readers that no difficulty was experienced, notwithstanding that the tools were made the same as for working brass. The precaution necessary, however, to assure satisfactory results was the use of a proper lubricant, which was a cheap grade of vaseline. For deep draws in this metal use lard oil.

A NICE JOB OF BENDING AND FORMING.

Fig. 489 shows the blank to form Fig. 491. This blank was 7 inches long by $2\frac{1}{4}$ inches wide, and was of hard brass $\frac{1}{16}$ inch thick. The corners were to be sheared to the radius shown, three holes were to be pierced at each end, and a slot was to be punched in the centre.

It was considered more economical to shear the strips of stock to the required width. The tools, Fig. 492, were of the "gang" type, performing the operations on the blank successively, and lastly cutting off the piece to the required length. In the die section *V V* indicate two of the piercing dies. They are hardened and ground steel bushings let into counterbored seats in the cast-iron die-block. *X* is the slotting die located in a channel in the face of the die-block by means of a strong dowel at *Y*. *Z* is the corner-trimming and cutting-off die, located in the die-block in the same manner as the die *Y*. The gauge-plate extends along the entire length of the die, while the stripping arrangement consists of four straps fastened by round-head screws *T*. By making the die in this way any injured part could be taken out and replaced independently.



F.G. 489.

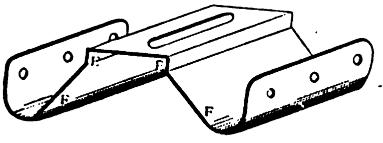


FIG. 490.—After First Bending Operation.

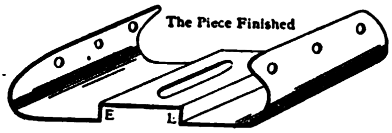


FIG. 491.

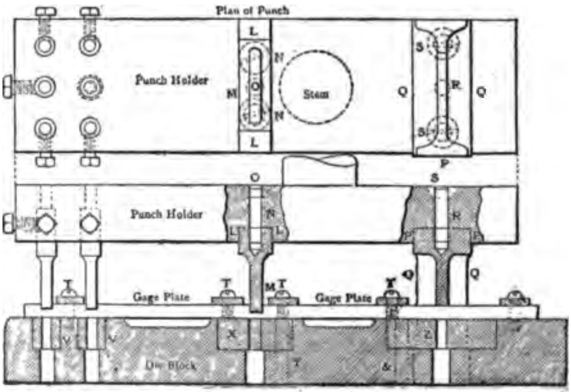


FIG. 492.

The punch consists of a cast-iron holder in which are located all of the small punches, five of which are fastened in their counterbored seats by means of set-screws *J*, while the inner central one is fastened by a flat-head screw let in from the back of the holder. The slotting punch *M* is located in a square channel in the holder by dowel *O* and two flat-head screws *N N*. The trimming and cutting-off punch is located in the same manner in channel *Q Q* by dowel *R* and screws *S S*.

The slotting punch *M* is the longest, while the cutting-off punch is the shortest. This is so that, the stock being fed from left to right, the slotting punch will pierce the stock first and locate it while the six holes are being pierced, and the cutting-off punch will not commence to cut until all other punches have entered their dies. Thus the accurate sizing of the blanks and the location of the various operations is assured. With this die an adjustable stop, not shown, was used.

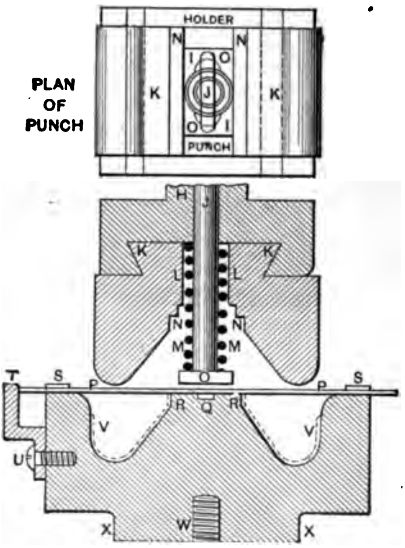


FIG. 493.

The result of the first bending operation on the blank is shown in Fig. 490, and to perform it the tools shown in Fig. 493 were used. The sketches are so clear that very little description will be necessary. The punch-holder is of cast iron dovetailed on the face at *K K* for the punch of tool steel, which is worked out to the shape shown and hardened at the bending face. The locater *O* and the spring arrangement are self-explanatory. The die also is of tool steel and is machined to fit the bolster and has a tapped hole at *W* for fastening screw. *P P* indicate the blank in position for forming, while the dotted lines *V V* indicate it as formed into the die. *S S* are the side gauges and *T* the end locating point. In use, the press in which the dies were located was inclined, and the work after bending fell off at the back.

For the last operation in the production of Fig. 491 the very simple tools illustrated in Fig. 494 were used. The work before finishing is indicated by the dark portion *O O* in position on the locater *L*, while the dotted lines *P P* show it as finished. The punch, of tool steel, is machined to fit the dovetailed channel in the face of the holder (not shown) and at *I I* to fit the central formed section of the work; the die is of cast iron.

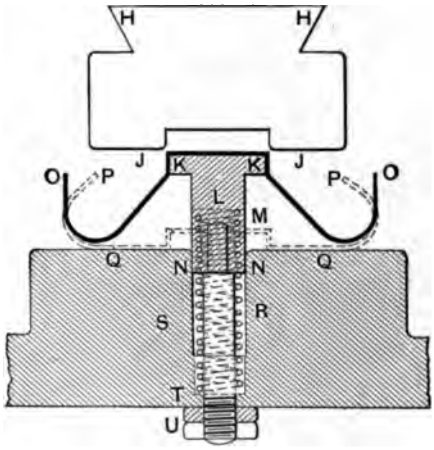


FIG. 494.

The rapidity with which these two bending dies can be worked and the quality of the work done by them are surprising when the simplicity and cheapness of the tools are considered. Some may think that it would have been better to have designed a die which would do all the bending in one operation. Possibly, if a sufficient quantity of the articles were required—say several millions.

"GANG" PUNCH AND DIE FOR PRODUCING EYELETS IN ONE OPERATION.

As an example of what is being accomplished in the devising of means for the production of sheet-metal articles in one operation I illustrate and describe here a "gang" die of very interesting type. A number of these dies were designed and put into successful operation by the writer not long ago for the production of one of two parts of a metallic button. They will be found the best to adopt for the manufacture of small buttons, eyelets, shell rivets, and anything of like nature that it is necessary to produce cheaply and in large quantities. To secure the minimum cost of operation, the stock is usually fed automatically by means of a fine-tooth ratchet roll-feed, thus securing fine adjustment of the stroke.

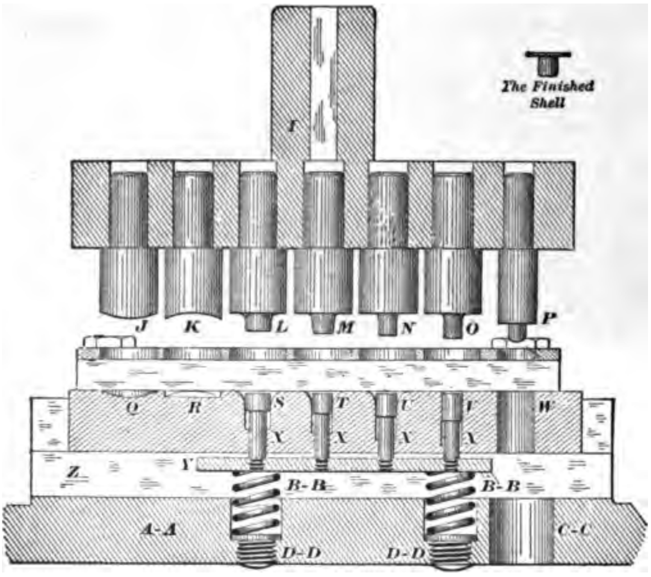


FIG. 495.

In brass work, where we can get our stock in long lengths, or in rolls approximately uniform in width, a die of the type shown in Fig. 495 will run off the entire strip or roll without the possibility of error, thus allowing of the press attendant looking after several presses and keeping them running continually.

Now, in the first place, be it understood that in order to draw sheet metal into any form or shape, it is first necessary to provide a blank. And when the article drawn is produced progressively, as in the die here shown, it is necessary, first, to cut the blank partly from the strip so that it may decrease in diameter with the drawing in such a manner as in no way to disturb the relative distance between the centres of the different operations required to produce the shell. This is the point which many die-makers forget, so that the dies prove defective where means are not provided for first *partly* cutting the blank, and there is no possibility of locating the successive operations in their proper positions, because of the metal which goes to form the cup being drawn sidewise and lengthwise in the first drawing. And as this will continue with each draw, there will be no likelihood of accurately locating the different operations. The way in which a "gang" die of this kind should be made in order to attain the desired results, will become apparent to the practical reader in the description of the tools here shown.

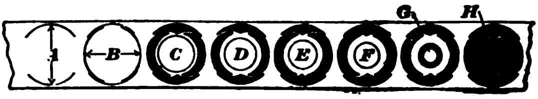


FIG. 496.

The punch and die were used to produce small shells like the one shown at the upper right of Fig. 495. And it required seven workings to produce the shell, finishing it complete from flat stock at the rate of 40,000 to 50,000 per day of ten hours. The stock used was .030 soft brass.

As the illustrations of the die and punch show clearly the various parts used in the construction of the tools, and Fig. 496 the results accomplished at each operation in the progress of the strip across the die face, very little description will be necessary.

The stock is first cut as indicated at *A*, Fig. 496, by punch *J*, Fig. 495, and then at *B* by punch *K*. Thus, the blank is produced so as to remain attached to the strip and to allow of being drawn and decreased in diameter by the subsequent operations without affecting the position of its centre in relation to the strip. This will allow of the metal being drawn into the shell and still leave a margin to hold the cups together and allow of feeding them along for the next operation.

The stems of the seven punches *J K L M N O* and *P* are let into reamed holes in the holder *I* and are fastened with set-screws, not shown. The punches were all hardened, drawn, and carefully lapped to size and shape. The die is finished in the usual manner, formed counterbores being used to finish the drawing and sizing dies. *Q* is the first cutting die, *R* the second, *S* the first drawing die, *T* the second, *U* the third, and *V* the sizing and finishing drawing die, while *W* is the blanking and trimming die. Each of the drawing dies is furnished with a plunger, which is hardened and drawn and let into pad *Y*. These plungers serve the double purpose of holding the metal while being drawn and of stripping it from the dies afterward, thereby leaving the stock free to be fed forward to receive the next operation. A channel planed lengthwise in the bolster *A-A* at *Z* allows the pad *Y* to work up and down with the action of the press ram. The two springs *B-B B-B* keep the plungers up with sufficient tension to hold the metal securely between their faces and the faces of the drawing punches while the drawing and reducing are being accomplished. Their pressure is adjusted or regulated by the headless screws *D-D D-D*. The trimming or blanking punch *P* has a pilot pin which fits the last drawing snugly and locates it true and central for being trimmed and blanked clean off the strip.

As the results accomplished by the use of such tools as are herein described and illustrated would require three or more operations if the simpler tools were used, it is no hard matter to figure out what the saving is.

In conclusion I might state that there is any variety of small drawn, formed, or embossed sheet metal work that could be produced more accurately and in half the time by the use of just such dies as that shown here. In order to succeed with these tools, however, always remember, before attempting to draw and form cups progressively from the strip, to *provide means for partly cutting the blanks from which to draw the cups.*

COMPOUND DIES FOR PARTS OF TELEPHONE TRANSMITTER CASES.

In Fig. 497 are shown the assembled parts of a telephone transmitter case of sheet metal, and in Figs. 498 to 503 the dies used for producing the parts. It is needless to state that these cases are used in great quantities and that the dies for their production are required to be of the most accurate and lasting construction in order that the parts may be produced rapidly and in exact duplication. As the work involved in the production of the transmitter-case parts consists of blanking, drawing, forming, piercing, and wiring, the dies are interesting, and engravings of them, together with the description of their construction and operation, will prove suggestive in the adoption of similar tools for the production of a large variety of drawn sheet-metal work, accurately and economically.

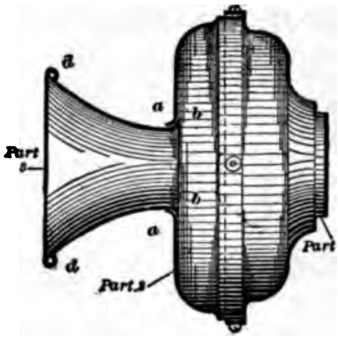


FIG. 497.

As will be seen from Fig. 497, the case consists of three parts, designated 1, 2, and 3, respectively. The part 1 is of an artistic shape and represents a nice job in drawn work. The die used for producing it is shown in Fig. 498 and was, as were all the blanking and drawing dies used in the production of the case parts, of the compound double-action type of construction. As a great many tool-makers are not familiar with drawing dies of this type, a slight description of their use will contribute to an intelligent understanding of their making.

Double-action dies derive their name from the fact that they are used in double-action presses to cut a blank and at the same stroke draw it into shape without the help of springs or buffers, as in the case combination single-action dies. The kind and thickness of the metal used determine whether one or several operations will be necessary to obtain the desired shape and depth in the article. There are two essentially different types of double-action dies, viz., Fig. 498 is a "solid-bottom die," and Fig. 501 a "push-through die." However, they are both used in the same way.

Taking the die Fig. 498—which was used for producing the part 1 of Fig. 497—*G* is the die bolster, in which the drawing and blanking dies are located. It will be understood that all parts of this die had to be constructed very accurately, that the working parts were hardened, drawn, and ground and lapped smooth in order to produce the parts as required. In the die, *A* is the main drawing die, which is located in a taper seat in the bolster, while *F F* is the blanking die, located in a seat in the surface of the bolster and secured by means of the two fillister head-screws *H H*. *N* is a stripper of the usual type.

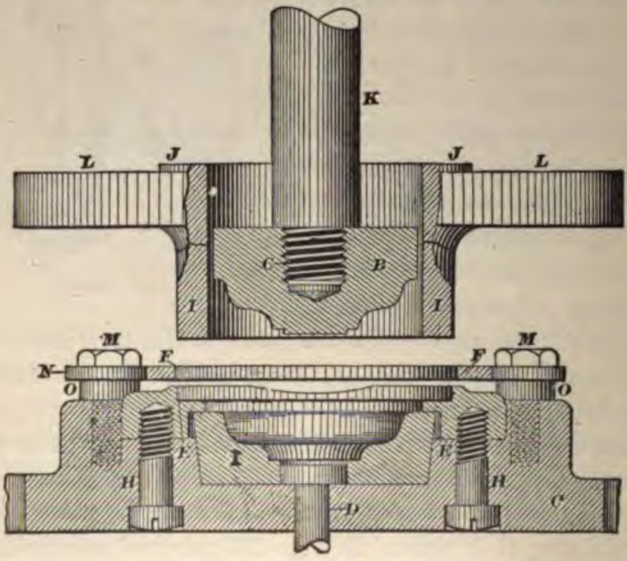


FIG. 498.

In the punch section, *L L* is the combined cutting punch and blank-holder; a forging of mild steel with a tool-steel ring welded on to one side to act as the cutting punch *I I*. It was machined all over; being turned at *J J* to locate on the face of the outer ram of the double-action press, and was hardened and drawn at *I I* and then ground to fit the cutting die *F F*, after which the face was lapped so that the blank would be held evenly while being drawn. *B* is the drawing and forming punch and *E* its stem. The manner in which this die was used, as well as the other double-action dies shown here, will be understood from the following:

The lower or die section *G* is fastened to the face of the press bolster, while the combined cutting punch and blank-holder *I I* is fastened to the face of the outer ram, and moves slightly in advance of the drawing punch *B*, the stem *K* of which is fastened in the inner ram, by which it is actuated. The outer ram of the double-action press being so arranged that, after making its stroke, its stops during about one-quarter revolution of the crank-shaft, and the combined cutting punch and blank-holder cuts the blank at *F F*, carries it down to the inner surface of the cutting die; holds it there tightly and remains stationary, holding it between the annular pressure surfaces of the punch and *E E* during the down "dwell" of the outer slide.

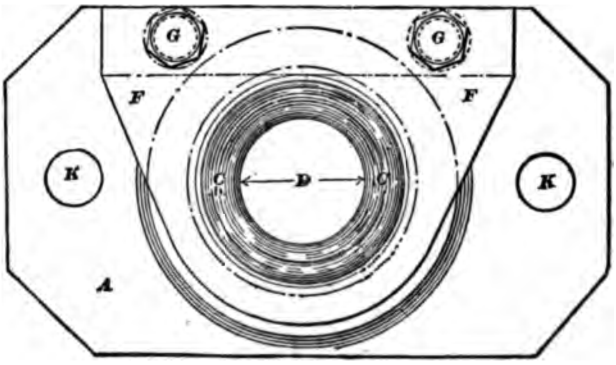


FIG. 499.

While the blank is under a pressure which has been regulated to suit the special requirements of the case, the drawing punch *B* continues its downward movement, thus drawing the metal from between the pressing surfaces into the shape required. As the punch rises the combined blank-holder and cutting punch remains stationary until the drawing punch has disappeared within it; then it rises also. At the completion of the up-stroke a knock-out attached to the press actuates the die knock-out *D* which delivers the finished shell at the top of the die. Some very close work and careful grinding, lapping, and polishing were necessary in order to get this die to produce part 1 as was desired, the metal used being sheet brass $\frac{1}{16}$ inch thick, the utmost care being necessary to get the difference in the diameter and curves and shape of the punch and die exactly two thicknesses of metal.

The punch and die used for producing part 2 of Fig. 497 is shown in Fig. 500. Although a compound double-action die, it will be seen that it is constructed differently from the one shown in Fig. 498, and that different results are accomplished in it. In this die the shell, forming part 2 of Fig. 497, is blanked, drawn, formed, and a hole pierced in the centre, to admit the end of part 3 as shown at *a*, Fig. 497, at one stroke of the press. However, the use and operating of the die are the same as explained for the first. As in the other, close and careful work were necessary on all the parts in order to have the die work well in the press. In the die section, *R R* is the cast-iron bolster, *P P* the combined cutting and drawing die, and *Q Q* the combined bottom-forming and hole-piercing die.

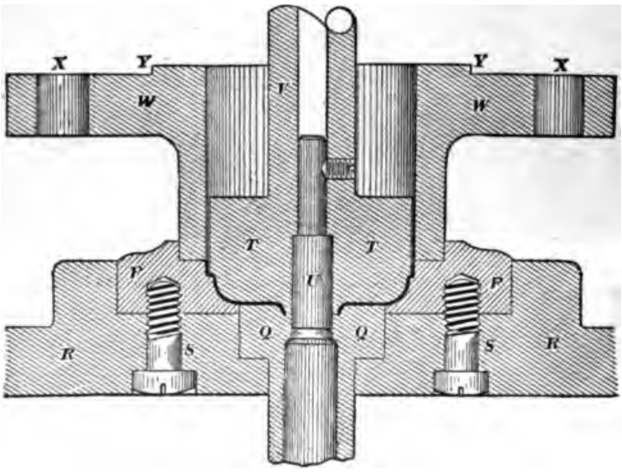


FIG. 500.

In the upper section of die, Fig. 500, *W W* is the combined cutting punch and blank-holder, a forging *T T* the drawing and forming punch, and *U* the hole-piercing punch. The manner in which the metal is cut, drawn, formed, and the hole pierced, may be seen from the dark section. In this die the bottom-forming and hole-piercing die *Q Q* also acts in the capacity of a knock-out; it being actuated on the up-stroke of the press rams by the knock-out device attached to the press. The blank produced by the hole-piercing punch *U* finds egress through an enlarged hole running entirely through the stem of the piercing-die section. Ideal results may be accomplished in a die of this construction, as the holding of the blank while it is being drawn is perfect; an even pressure being maintained all the time, which is not the case when single-action combination dies are used, as the tension on the blank is communicated through a rubber spring barrel which compresses as the blank-holder ring descends and thus renders the tension uneven. Thus, deep draws cannot be attained in a single-action die through the metal tearing or splitting because of too much pressure on the blank as the draw nears completion; while in compound double-action or triple-action dies, draws of considerable depth, in comparison with the diameters, can be attained because the pressure on the metal is exerted by cams on the crank-shaft and is, of course, even.

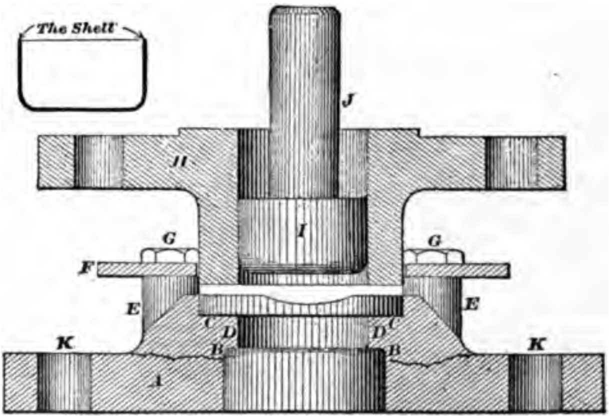


FIG. 501.

To produce part 3 of the case, to the shape shown in Fig. 497, three operations were necessary. The first consisted of drawing a shell of the shape shown at the upper left of Fig. 501. This shell was blanked and drawn in the double-action "push-through" die shown in Fig. 501. As will be seen, the die section is in one piece. It was a forging of mild steel at base, with a tool-steel face for the cutting die. The weld of the two steels is indicated by a wavy line in the drawing. The machining and finishing of the die were accomplished in the usual manner; all working parts being left over size, and ground and lapped to a finish after the die had been hardened and tempered. *A* is the base, *C C* the cutting die and blank-holder portion, *D D* the drawing die, and *B B* the stripping edge.

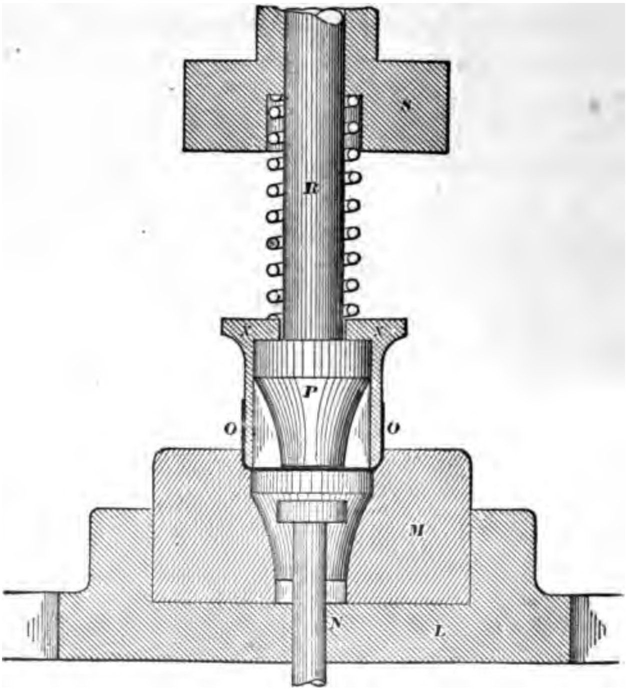


FIG. 502.

In the punch section of Fig. 501, *H* is the combined cutting punch and blank-holder and *I* the drawing punch. As will be seen, the die is equipped with a stripper of the usual construction. This die was a far more rapid producer than the other two, as the metal was cut, then drawn and pushed through the die, stripping at *B B;* thus obviating the necessity of a knock-out and the delivering of the drawn shell at the top of the die.

The second operation in the production of part 3 was accomplished by means of the tools shown in Fig. 502. These tools require little description as their construction and use are almost evident at a glance. *S* is the punch-holder, *P* the drawing punch, and *R* its stem; while *X* is the inside blank-holder which supports and holds the shell on the inside while it is being reduced and formed; *Q* is the stripper. In the die, *L* is the bolster, *M* the die, and *N* the knock-out for stripping the finished work from the die. The punch and die were operated in a reducing press with a stroke of considerable length.

The last operation in the production of part 3 consisted of punching out the bottom at *b b* and wiring the edge at *d d* as shown. This work was accomplished entirely by the use of the combination wiring and piercing die shown in Fig. 503. Although the drawing is very clear, a description may assist many to understand intelligently the construction and working of the tools.

In the lower section, *T* is a cast-iron bolster, bored out and recessed for the hole-piercing die *U U* and the holder and locator *V V*. The piercing die was of tool steel, hardened, ground, and lapped to size, and a force-fit into its seat in the bolster, while *V V* was of mild steel worked out on the inside to fit the formed shells and turned taper on the outside to drive into the taper seat in the bolster.

The upper section consists of, first, the holder *B*, a forging of mild steel worked and machined as shown, to contain the wiring die *W W*, the spring stripper and work supporter *X X*, and the piercing punch *Y*. As will be seen, the wiring die is located in a seat in the holder-face and fastened by means of fillister head, screws, while the piercing punch is located in a reamed hole running entirely through the holder, and is permanently secured in position by means of a taper pin at *A*. The spring *D D* exerts enough pressure on the combined work-supporter and stripper *X X* to allow of it supporting the shell on the inside while it is being wired by the die *W W*, and then stripping it from the piercing punch at the rise of the press ram.

When the punch and die are in use, the shell is slipped into the locating seat in *V V* and the press stepped. As the punch descends, the supporter and stripper come in contact with the inside of the shell and hold it tightly while the spring compresses and the rest of the punch parts continue to descend. Then the edge of the shell enters the wiring groove and follows around its curves; the punch descending until the curl is complete, the piercing punch *Y* having meanwhile punched the bottom out of the shell and into the die *U*. At the up-stroke of the ram the stripper *X X* remains stationary until the piercing punch has left the shell and the wiring die has risen above it; then it rises also, leaving the finished shell in a position to be easily removed.

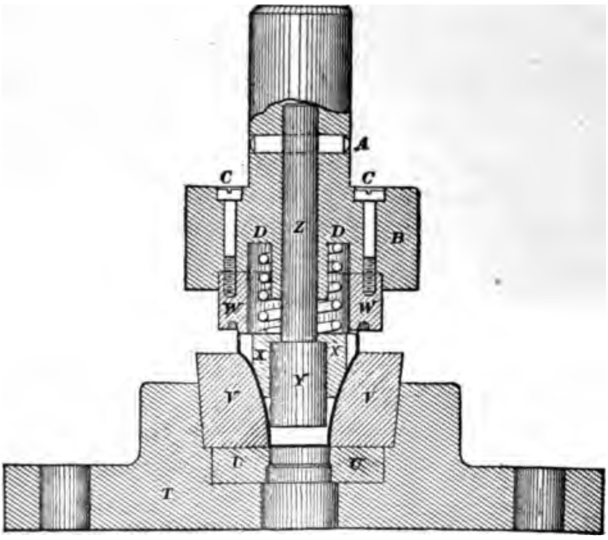


FIG. 503.

The other operations necessary to allow of the parts of the transmitter case being assembled as shown in Fig. 497 consisted of joining parts 3 and 2 together as shown, and piercing four holes in the rims of parts 1 and 2 for screws. But as the tools used for those latter operations were very simple, their illustrating and describing are unnecessary.

In conclusion, I might state that it would be well for manufacturers of artistic drawn sheet-metal articles and parts to give more attention to the use of double-action dies and double-action presses, as the results accomplished by their use are not to be compared with those accomplished by combination dies in single-action presses.

CHAPTER XXVII.

Processes, Presses, Devices, and Arrangements for the Rapid and Economical Manufacture of Sheet-Metal Articles.

PRESS WORK.

It is only during the past few years that the use and value of the power press and hydraulic press for sheet-metal working have come to be almost universally appreciated and known, and to-day the rapidity with which their use is being extended is astonishing.

Among the machine-tool brood the power press and its work occupy a unique position in one respect, as it is the only machine tool, and its operation involves the only process, in which, after the material is once cut off from the sheet or bar, there is no making of chips or waste. The press, as such, does neither cutting or abrading.

To be sure, the power press is usually a more or less expensive machine, and the devising and constructing of suitable dies for it requires the employment of the most skilful mechanics and is often among the most expensive work of the trade. But when the machine and dies are in successful operation the saving of labor in production is enormous, and is greater than that saved by any other machine tool. In fact the most elaborate and costly articles are often numerously produced by the power press, which could not be made by other processes for one hundred times or even one thousand times the cost.

Until lately the power press, by reason of its rapidity of production and the manifolding of its product, was distinctly a factory machine. But to-day this same machine is employed almost universally in up-to-date machine shops for the production of an endless variety of parts which are used on machines, and it is to be reckoned with the same as the other machine tools; that is, as an economic producer of shop products.

PERFORATING FLAT AND CYLINDRICAL SHEET METAL.

In the production of plates and articles with numerous perforations, dies accompanied by novel mechanical devices play a more important part than any other line of sheet-metal work. While the dies used in such work are comparatively simple, the devices and appliances used in connection with them are often intricate and novel. Especially is this so in the perforation of cylindrical articles and parts, where the die remains stationary and the shell is rotated successively at each stroke of the press, until the entire surface has been worked upon. By means of these rotating devices shells may be perforated in any design or pattern of perforations by means of a single row of dies, the manner in which the shell is rotated after each stroke determining the pattern of the perforations. Anyone who has noticed the odd, novel, and artistic designs in the perforated shells used on gas and lamp burners and fixtures must have wondered how they can be produced so cheaply. The secret lies principally in the devices used for rotating, and farther on I show a number of such devices and the dies and tools used with them.

In the perforating of flat sheets of metal the construction of the dies used is equally similar to that followed out in the "gang" types, and they are used on work ranging from ornamental sheet-metal articles to the punching of holes in steel beams and boiler plates. The holes pierced with this type may be of any shape desired and may be spaced in any manner or combinaton. Often the usual conditions are reversed and instead of the perforations being desired, small blanks are the objects sought, a number of them being fed to the dies automatically. Perforated sheets of the different metals are now in great demand and are used for a variety of purposes too numerous to mention.

ATTACHMENTS FOR CYLINDRICAL PERFORATING.

In Fig. 504 is shown a horizontal two-slide foot press for punching simultaneously two holes or slots on opposite sides of drawn shells. The die is located in the centre and is made with cutting-edges on opposite sides and with a clearance hole through the bottom as an escape for the scrap or punchings. The punches are of steel rod fastened in punch-holders or chucks which are adjustable and mounted on slides provided with adjustable gibs. Each slide is arranged with an adjustable stop to allow of piercing shells of different diameters. Dies of this type, when used in a machine of the kind shown, are very convenient for rapidly and accurately producing pierced shells for lamp-burners, satchel locks, and a variety of other pierced work requiring holes pierced on opposite sides.

Figs. 505 and 506 show two different sets of perforating fixtures in position on presses for perforating burner shells and other cylindrical sheet-metal articles. Fixtures of these types are used extensively for work which it is desired to perforate all around, although sometimes used to perforate in sections only.

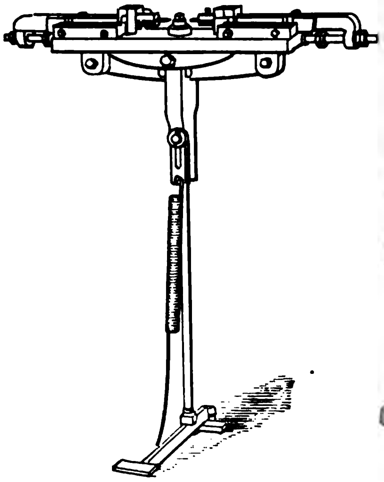


FIG. 504.

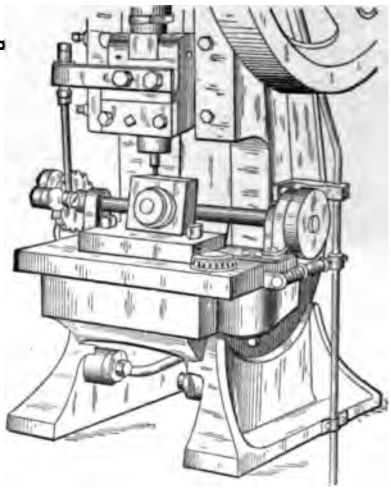


FIG. 505.

The attachment shown on the press in Fig. 505 is used for taper and crowning shells, which necessitates the setting of the die-holder and rotating device at an angle with the lower face of the slide. The shell, as perforated, is shown on press bolster at the right.

Fig. 506 shows a press equipped with dies and fixtures for perforating small close patterns in bottomless shells. As will be seen from the engraving, in which a die, punch, and two perforated shells are shown on the floor, the die is a piece of steel with two rows of holes in it and dovetailed into the work-holder, while the punch is equipped with a spring stripper and two rows of piercing punches. The dies shown located in the press are for perforating the small shell, and the ones on the floor for perforating the large one shown at the right at the bottom.

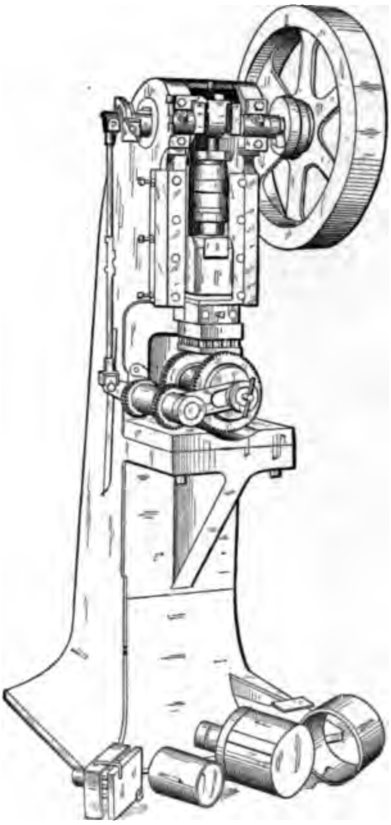


FIG. 506.

In the attachments of the types shown in Figs. 505 and 506 the perforating dial with a chuck of suitable shape is mounted on a die-holder, and a ratchet having teeth spaced to suit the holes or pattern desired is mounted and arranged to rotate the shell at each stroke of the press. By the use of such attachments, perforating may be done at the rate of 150 to 200 strokes per minute.

The adjustment of the parts of these perforating attachments is easily and quickly made, so that but a short time is required to change the attachments from one style of shell to another. Presses in which such attachments are used are often provided with a latch lock for the clutch connection, which is automatically released after each complete rotation of the article on the perforating chuck, thus stopping the press automatically after the requisite number of strokes have been made.

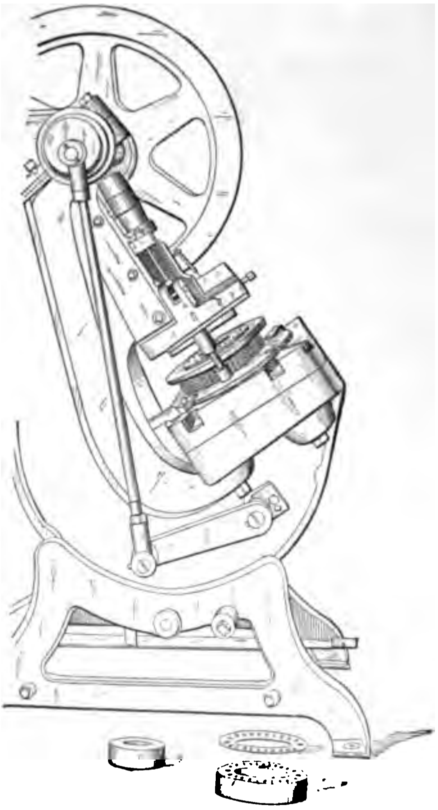


FIG. 507.

PIERCING AND BLANKING SMALL ARMATURE DISKS.

In Fig. 507 is shown a set of dies as located in an adjustable press for accurately piercing and blanking armature disks for small generators and motors. The press is furnished with an automatic knock-out, and its inclined position allows the blank, after being punched and pierced, to be lifted out of the die and slid off at the back. The pierced blanks are usually punched from strips sheared to the necessary width. The construction of the dies is such as to allow the outside and the inside to be punched simultaneously, after which it is held between the faces of the blanking punch and the pad, and descends far enough for the piercing punches located around the die to pierce holes. The finished disks are shown beneath the press.

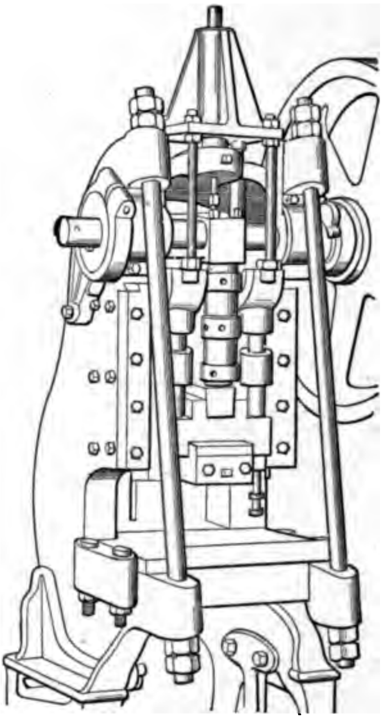


FIG. 508.

KEEPING SHEETS OR ARTICLES STRAIGHT WHILE PERFORATING.

For perforating articles of considerable size, or flat plates which are required to be kept straight, dies of the usual construction will not do good work, as on such dies stationary strippers are used and they are liable to distort the metal to such an extent as to require subsequent straightening. To overcome this defect a press equipped with a cam-actuated stripper should be used, especially on accurate work, such as parts of clocks, electrical instruments, etc. A press equipped in this manner is shown in Fig. 508. The stripping device is such as to leave a clear space between the punch and die, thus allowing the operator to manipulate and observe the work at will. The action of the stripper when the press is running is as follows: The stripper plate strikes the blank or article first, straightening and clamping it before the punches enter, and holding it under pressure while the punching and stripping are being accomplished. In this manner the flat or formed piece comes out perfectly straight and true. The punches used when a press is equipped with a stripper of this type may be made considerably shorter than where a die with a stationary stripper is used, thus making them more durable. Also by this arrangement a smaller hole in proportion to the diameter of the punches may be pierced, through the support given the punches by the movable stripper up to the point where they enter the stock.

PERFORATING LARGE SHEETS OF METAL IN SPECIAL DESIGNS.

For the perforating of large sheets of metal in designs similar to those shown in Figs. 509, 510, and 511, special feeding arrangements are used. Some of the patterns are staggered and others are regular, and to produce them a single row of "gang" punches and dies or a double row is used. When a double row or "gang" of punches and dies is used, the metal is usually fed automatically by means o feed to a press of large and powerful construction. ction of the punches and dies for such work is such as to allow of removing any one or a number without disturbing the others. The punches are usually located in a cast-iron holder which is fitted to a dovetailed channel in the face of the press ram. They are short and stocky and fastened by set-screws. The dies are usually tool-steel bushings, hardened and ground, and let into holes drilled and reamed in a bolster of similar make to that used for the punches. The bushings also are fastened by set-screws. With a powerful press equipped with proper feeds and punches and dies the author has seen 154 ⅜-inch holes punched in ¼-inch plate at each stroke of the press. The press referred to was used in the works of a large agricultural machinery concern and was provided with a roller feeding attachment consisting of four adjustable rolls, 6 inches in diameter and 54 inches long, which fed the stock automatically in multiples of sixteenths of an inch up to four inches. For heavy work the press was provided with back gears, which were thrown out when doing light work, so as to give the press a higher speed. The slide adjustment on this press was such as to allow of raising or lowering it to overcome the shortening of the punches through wear.

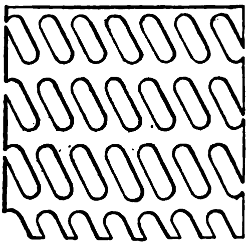


FIG. 509.

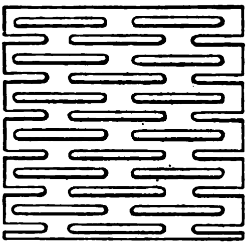


FIG. 510.

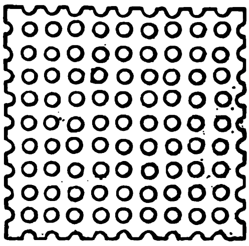


FIG. 511.

PRODUCTION OF PERFORATED METAL BY THE ALLIS-CHALMERS COMPANY.

One of the largest producers of perforated metal in the world is the Allis-Chalmers Company, of Chicago. In their shops improved machinery is being constantly provided for the production of perforated metal in the endless varieties which modern demands necessitate. The chief aim in this plant is to produce the material at the lowest cost and in the shortest time possible. This object, of course, can be attained only by keeping the machines constantly producing perforated sheets of the same design and pattern. Most of the output in this line produced in the above-mentioned shops is used for rotating screens for stone, grain, coal, ore, etc., the perforated plates being rolled to exact diameters in special machines. For such purposes perforated metals have superseded and are far superior to wire cloth; being much stronger, more uniform in size of hole and mesh, less liable to tear or rust out, and in case of breakage they may be easily repaired or replaced without affecting the entire sheet. In screens for various purposes it is often desirable to arrange them with portions left blank. This can be easily done when perforated metal is used, as the sheets can be perforated in a press equipped with a feed which can be adjusted to feed unequal spacings.

HORNING AND SEAMING PROCESSES.

In the manufacturing of pieced sheet-metal ware, the processes of "horning" and "seaming" play a very important part, and a large variety of ingenious devices and fixtures is used, giving rapid and accurate results. The processes are essentially assembling and preparing ones, as they assemble flat, round, and

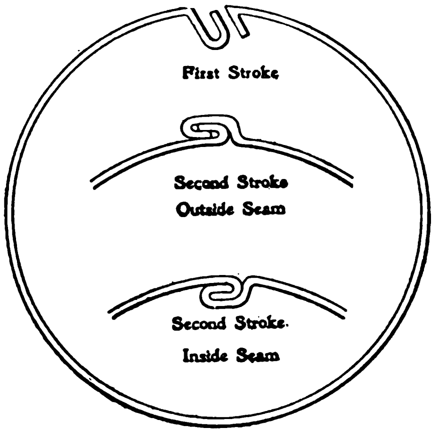


FIG. 512.

irregular parts, and often prepare them for subsequent operations of wiring, curling, etc. The successive stages of a "lock" seam are shown in Fig. 512 and a press equipped with the tools in Fig. 513. The manner in which an inside or an outside seam is finished is shown, two blows being necessary for each. The first operation is the forming of the hooks, and the second the crushing down and locking together. There is a large variety of work which requires finishing with locked seams of this kind.

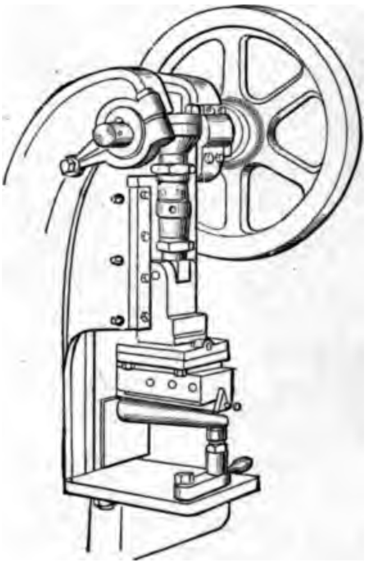
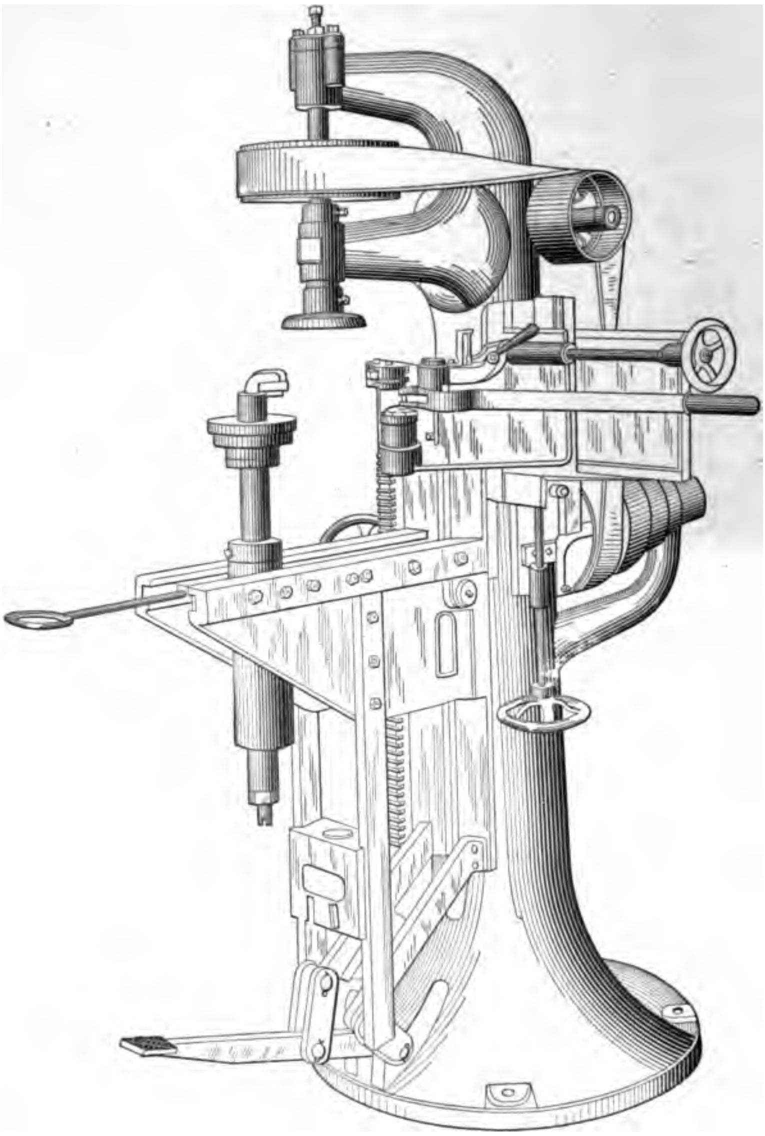


FIG. 513.

For the double-seaming of bottoms, tops, and parts of round bodies together, the work is accomplished by special machinery and dies are dispensed with. A machine for this work is shown in Fig. 514 and diagrams of the work done on it in Figs. 515 and 516. These machines are used extensively for double seaming "flat bottoms" on to tea-kettles, coffee-pots, pails, and similar goods in the tin and enamelled iron-ware line.

The lower spindle carrying the "inside chuck or roller" is mounted on a sliding plate, which is drawn forward for putting on and taking off the articles. In the case of flaring pails, dish-pans, and other articles which are smaller at the bottom than at the top, the double seaming is done against a solid plate of the size of the bottom, mounted on the sliding spindle. For buckets, cups, and other straight articles collapsible chucks are used. These chucks are so made that they spread to fit along the edge of the bottom when the article is carried up against the upper chuck, and fold together after the work is done to permit the rapid and easy removal of the seamed article.

For double-seaming bottoms or tops stamped or drawn with a burred edge, as per Fig. 517 and 518, a fixture called a deflecting device is required and may be readily attached to the machine. The diagrams show the steps in which the seaming is done; the deflecting device performs the second of the three



514.

operations. The use of burred-edge blanks for the bottoms of round work offers the advantage of easily centring the bottoms on the bodies. For a great many articles, however, plain bottom blanks are preferred. In that case the deflecting device is dispensed with, and instead of it two brackets are attached to the machine, carrying three adjustable rolls for centring the blanks or bottoms on the bodies, before clamping. For heavy stock it becomes necessary sometimes to have a slight depression in the centre of the bottom blank corresponding with a slight projection on the clamping plate, so as to prevent the pressure of the seaming rolls from pushing the bottom away from its central position.

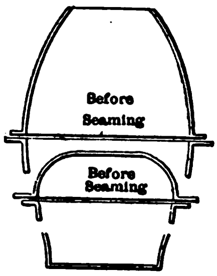


FIG. 515.

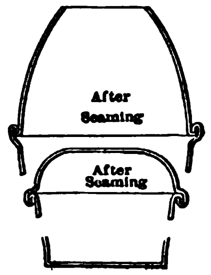


FIG. 516.

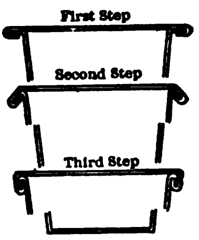


FIG. 517.

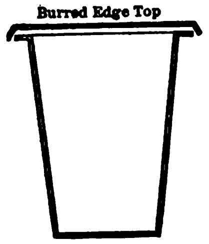


FIG. 518.

For a certain kind of work a press specially equipped with an automatic fixture for double horning or seaming is used. By means of this automatic fixture the two corner seams on large square cans having round corners with seams in the centre, may be closed at one blow. Tins with sharp corners require a "coaxing" operation on a single horn to start the seam over before setting over on a double-horn press. The horn, which is movable in ways, has two working surfaces, the upper one being acted upon by a "force" bolted to the press slide, while the lower one in descending with the slide acts against a stationary force fastened to the bed. It will be understood that the two body-halves of the can, loosely hooked together, are pushed over the sliding horn, as shown in Fig. 519, which, by means of adjustable gauges, secures accurate size and position. By the use of a double-horn machine the capacity of the operator is nearly doubled as compared with what can be done on an ordinary horn press. Presses equipped with fixtures for double seaming are used extensively for seaming 5-gallon petroleum cans, as per Fig. 520.

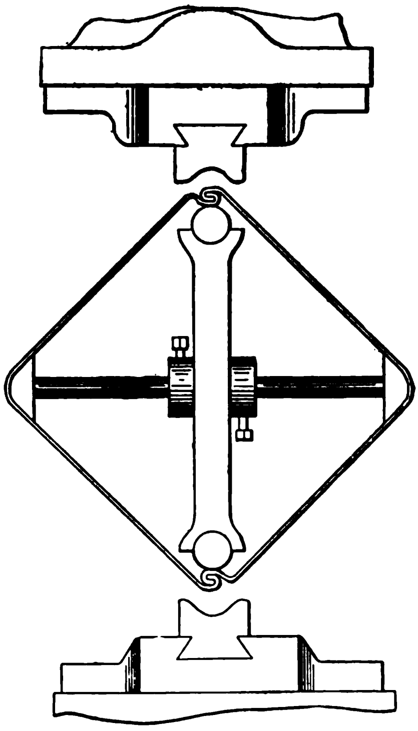


FIG. 519.

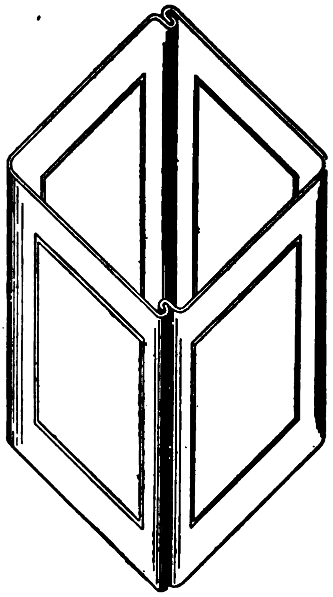


FIG. 520.

Double-seaming machines (Fig. 521) for seaming articles of irregular shape differ from those of the type shown in Fig. 514 in that they allow the seaming rolls to follow automatically the shape of the can. As they do the seaming at the top of the can, they are preferable for filled cans. In action, the pressure on the foot treadle, which causes the pressure plate to clamp the can and lid against the chuck, also throws in the friction clutch which starts the work. The double-seaming rolls, controlled by

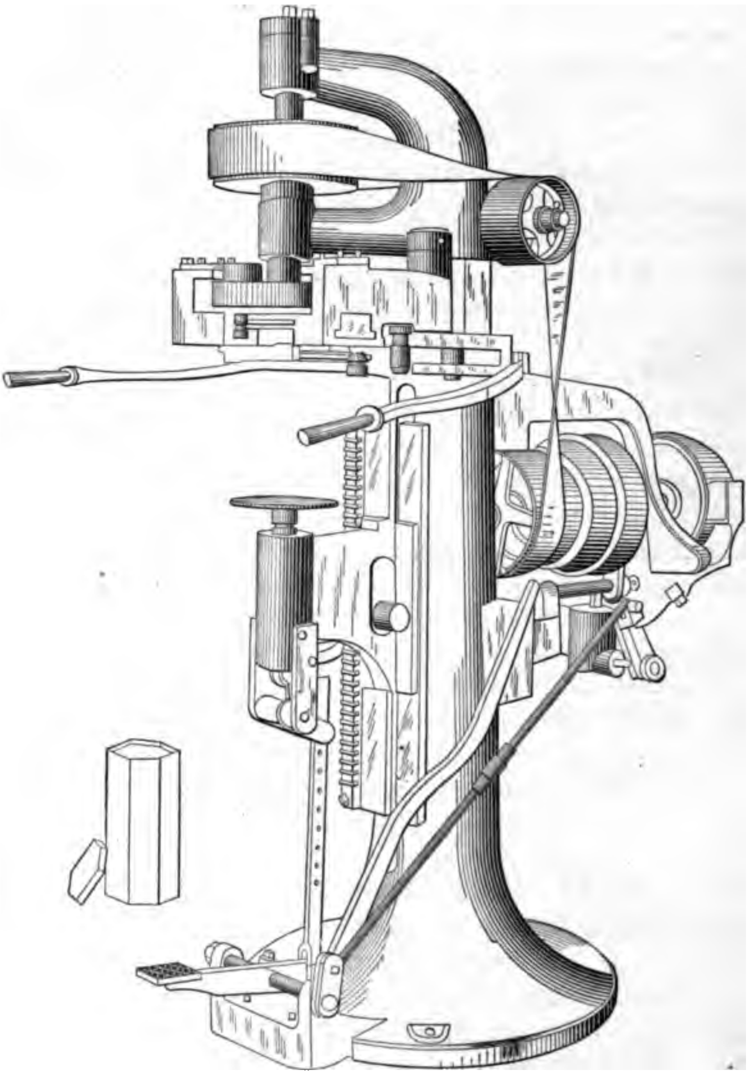


FIG. 521.

a cam made in a piece with the chuck and finished to the shape of the can, follow the shape of the can automatically, while the necessary pressure to form and finish the seam is imparted by the handles. These pressure handles in such machines are so arranged as to relieve the hand of the operator from all vibrations due to the irregular shape of the cans. Adjustments for different heights of work can be readily made by means of a hand-wheel, and for different shapes by exchanging the can chuck, which can be done in a few minutes.

The rolling of seams on square cans is usually accomplished in the following manner: The can is firmly held between two disks made exactly to fit the heads of the can; the upper disk being mounted on a vertical shaft fastened rigidly to the upper part of the main frame of the machine and the lower disk to a shaft passing through the lower part of the frame and prevented from turning by an arm running in the guides, but capable of vertical motion imparted to it by a cam on the treadle shaft.

The steel rolls which operate on the seam at the top and bottom are carried by a frame which rotates upon the upper and lower stationary shafts and revolves around the can. These rolls are mounted on levers pivoted in the rotating frame, the opposite ends of the levers being finished with rolls bearing against star-shaped stationary cams in two vertical shafts which gives the "in-and-out motion" required in passing around the corners of the cans. The rotating frame carries two sets of these rollers, which press upon opposite sides of the can at both top and bottom, thus equalizing the side pressure and rolling the seams more perfectly than would be possible by the use of the single set of rolls, each seam being rolled twice in each revolution. There are additional cams provided which, as the machine comes to a rest, move the rolls outward from the surface of the cam, so that the latter may be removed from the machine. Attached to the bottom of the rotating frame is a bevel gear meshing with a pinion on the pulley-shaft. The pulley is provided with a friction clutch controlled by the treadle.

A cam being placed upon the lower disk, the foot treadle is pressed and the can is raised and clamped firmly between the upper and lower disks. The clutch is then thrown in, and the roller frame makes one revolution around the can, the latter remaining stationary. After completing the one revolution the clutch is automatically released, the rolls are thrown outward and the lower disk drops, leaving the can free to be removed. The capacity of these machines is from 9,000 to 12,000 cans in ten hours, and the saving of solder alone by the use of each machine amounts to from $15 to $18 per day.

For double-seaming the bottoms on large heavy work, such as foot-tubs, bath-tubs, wash-boilers, cauldrons, and other large, oval, oblong, or square articles, when the bottoms are required to be fastened without the usual recess next to the double seam, a large machine of special design is used.

In this machine a high chuck is used, fitting the inside of the article, and the double-seaming is done against the inside of this chuck. In order to establish the correct position of the bottom blank in relation to the body, the blank is usually stamped with a slight depression at some distance from the edge, which fits a corresponding depression in the top of the chuck. To facilitate the taking off of high articles, there is usually an upper arm on the machine which carries the clamping-plate that is arranged to swing out of the way.

For the double-seaming of tops, bottoms, or parts of special shaped articles, special chucks and devices are necessary; however, the principles involved are all very much the same in all work of this class, and a knowledge of the methods in general use will enable anyone to accomplish the desired results without trouble.

CURLING AND WIRING PROCESSES.

I will here take up a class of press tools and fixtures to accomplish results in sheet metal which a few years back were possible to attain only by spinning. The operations in which these tools are used are curling and wiring operations, respectively. Curling is producing a curled edge around the top of any formed or drawn articles of sheet metal. Wiring is the curling of the top of such an article around a wire hoop when it requires stiffening. The tools used for either curling or wiring are of almost the same construction.

In straight work and work but slightly flared simple dies can be used to turn the metal, when wiring, around the wire and under it, perfectly at one stroke of the press. From 2,000 to 8,000 pieces can be wired per day of ten hours.

Figs. 523, 527, 530, and 531 show cross-sections of dies which may be used for curling the edges of circular drawn shells. Of course, it is impossible to see the action of the metal in work of this kind while the die is working, but by noting the condition of the shells at intervals during the curling, by working the die down and up by hand, the process can be seen and understood. The groove in the upper die (or lower die, as the case may require) must be finished at the back to a perfect half-circle of the radius required, and must be lapped and polished until free from all cuts and scratches, in order to get a clean, smooth curl. The sketches in Fig. 522 show how the upper die curls the edge of a half-round shell. In the first stage *A* the metal has commenced to curl; at the next stage *B* the metal has curled to a half-circle of the width of the curling groove in the upper die. At *C* the third stage is shown; the punch continuing downward; as the edge of the shell passes the centre of the curling groove the pressure is exerted on the top of the half-round curled edge and causes the metal to curl further around until the circle is complete, as shown at *D*. In this manner only one operation is necessary to curl the edge of a shell of the type shown, as the metal once started around the curling groove of the upper die will follow the curl on the same radius as long as the pressure continues, or until the edge strikes the side of the shell, when it will curl within the first curl. Thus a shell may be quarter curled, half curled or completely curled

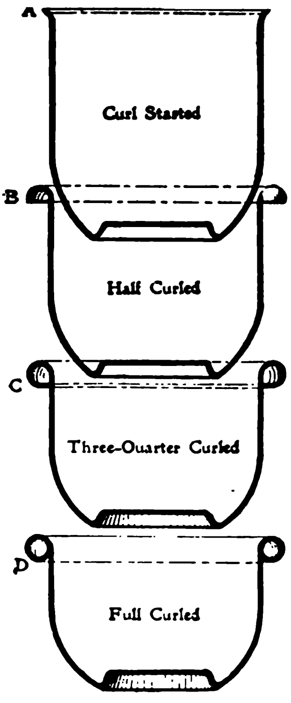


FIG. 522.

by the same die, according to the length of stroke to which the die is set.

When the edge of a shell of the shape shown at Fig. 524 is desired to be curled as shown at 526 the work will require two dies. The first die is to bend or form the edges to the upright position and the second die to curl the edge. This second die is shown in Fig. 527. The upper die is made so as to make the entering of the edge of the shell positive within the curling groove, and also so that the straight inner wall will hold the wall of the shell while the edge is curling, thus preventing any bulg-

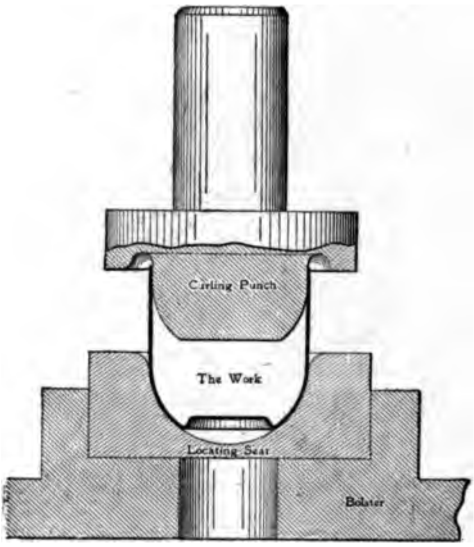


FIG. 523.

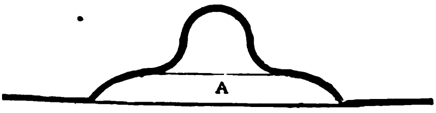


FIG. 524.

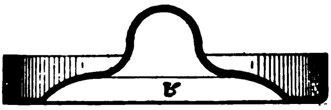


FIG. 525.

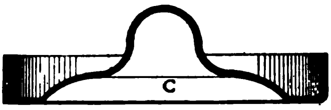


FIG. 526.

ing during the process, which would occur if the inside of the tool was finished like the outside. In this manner the metal is held tightly, and as the ram descends it must follow the shape of the curling groove.

The curling of the edges of drawn shells by means of dies of the above type is done in endless variety; the articles worked upon ranging from shoe eyelets to bath-tubs, of both round and irregular shapes. The design and construction of the tools depends on the shape, the thickness of metal, and the diameter of curl required; however, the principles of construction involved are the same in all of them.

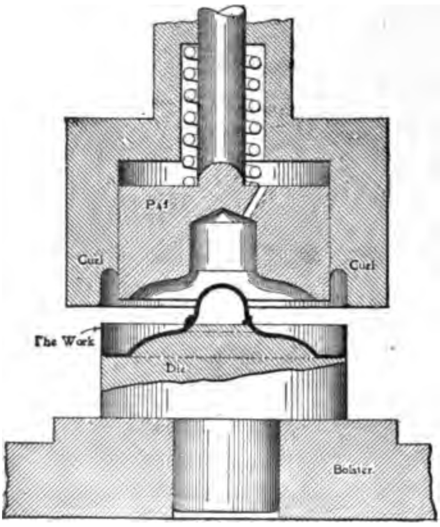


FIG. 527.

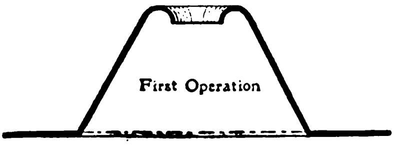


FIG. 528.

The tools in Fig. 530 show how shells of different shape may be curled. For the operation shown at *A* and *B* a combination die and a bending die, respectively, are used. The curling as shown at *C* is done in the die shown.

The manner in which curling dies are used for "wiring" on both large and small work will be understood from Figs. 531 and 532.

Dies of this type may be used for "wiring" or simple "curling" on round or oval shells, as long as they are straight or nearly straight walled, and are properly supported during the process. A tool-steel ring *A* is attached to the punch-holder. The inner diameter of this ring must fit accurately the inside of the shell to be wired, so as to prevent bulging or crimping of the walls. When "wiring," the ring *B* is used in the lower die.

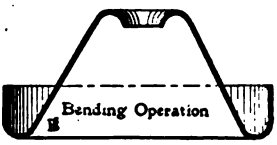


FIG. 529 a.

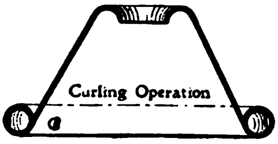


FIG. 529 b.

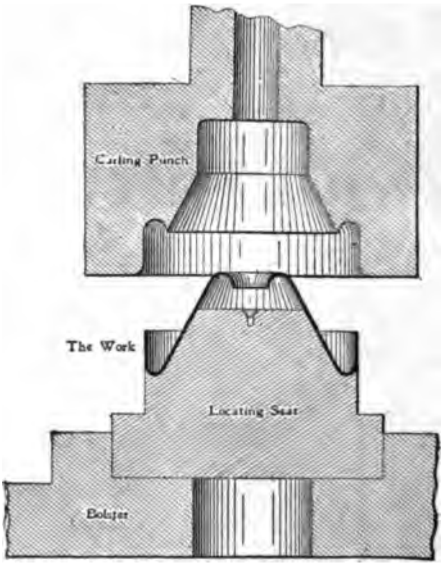


FIG. 530.

When the dies are in use a wire hoop, which fits the outer diameter of the shell, is placed in position on the ring *B* and around the shell which is located within the dies as shown. The ram then descends and the edge of the shell is curled around the hoop, enclosing it within it, as shown at the bottom of the cut.

A curling punch and die for curling deep shells or articles of thin sheet metal, and a section of the press in which it was used, are shown in Fig. 533. The punch is located and fastened within the ram, while the die is on a sliding table which may be pulled back and forth by the operator. The horn or die for locating the work is of slight taper, and consequently a solid one-piece curling punch can be used, as the decrease in diameter when curling is so slight that contraction of the curling ring is unnecessary. When in use, the table on which the horn or die

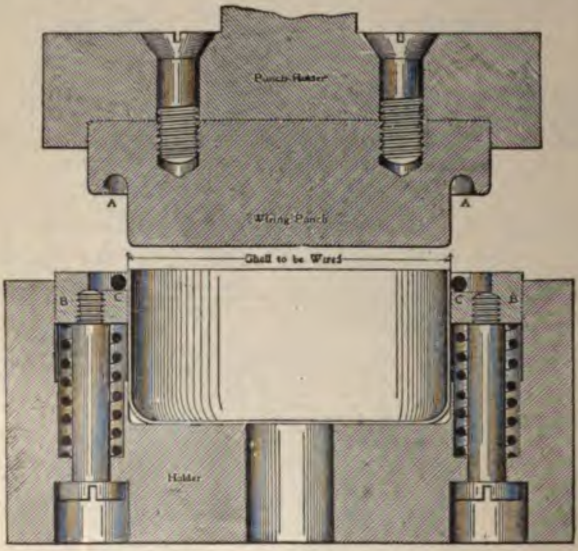


FIG. 531.

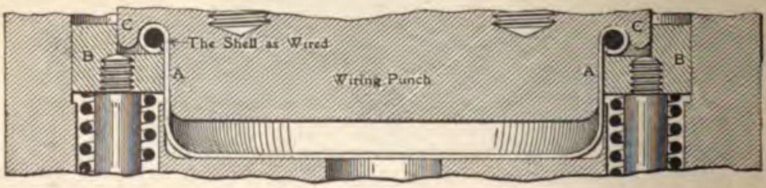


FIG. 532.

is located is pulled out to allow the article to be slipped over it. This is done, and the table is moved back to place against the stop shown. The punch then descends and the edge of the article is curled. The punch ascends, the table is pulled out, the work is removed, another piece is located, and the operation is repeated. When a press with an automatic die slide is used the curling or wiring is done more rapidly.

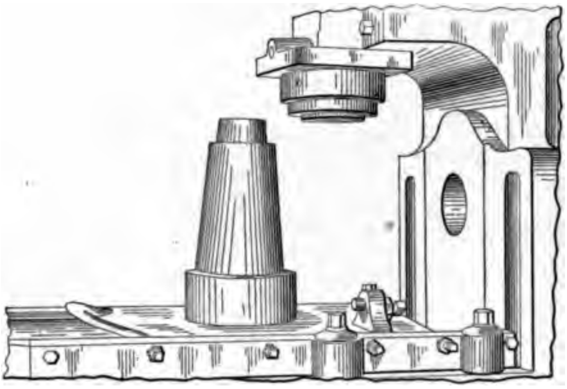


FIG. 533.

MANUFACTURING ARMATURE DISKS AND SEGMENTS.

The adoption and use of dies, power-presses, and special sheet-metal working machinery for the economic production of parts of electrical apparatus has had great development during the past few years; so that to-day establishments that manufacture sheet-metal working machinery dispose of a great portion of their product to electrical machinery manufacturing concerns. One has only to examine an electrical device or a machine to realize what a factor the power-press has become in their production. The parts of electrical apparatus for the production of which such machinery is used most extensively, are armature disks and segments for motors. It is at once obvious that the requirements for such work have led to the designing of dies, presses, and special machinery which differ in essential details from those used in the general and more familiar classes of sheet-metal working.

An armature consists of a wired "core" composed of thin sheet-iron plates or disks averaging from .010 to .040 thick and 10 to 100 inches in diameter. In many of the best armatures the disks are produced by punching the centre hole, key slots and notches, or winding slots, simultaneously at one stroke of the press. The small sizes are thus produced in dies, while the larger ones are produced in sections or segments of as large size as it is possible to procure iron for. In the cheap and inferior armatures the disks are first punched from plain sheets; the punching of the centre holes and the key slots is a second operation, after which the disks are assembled on shafts, the outside turned to the required diameter, and the slots milled on a universal milling-machine.

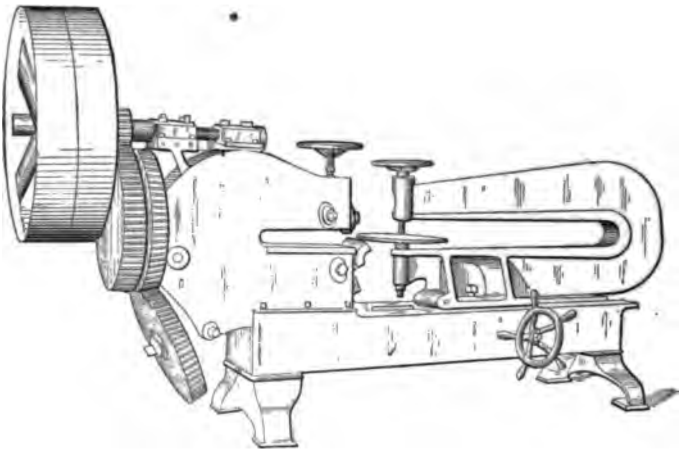


FIG. 534.

Machines and dies used for cutting and perforating armature disks and segments differ according to the size and shape and number or quantity required. There are in general use four methods for cutting armature disks. On the size and quantity of disks desired depends the practical value of each.

Disks of very large diameters, or those required in relatively small lots, are usually first cut plain by shearing the outside circle and afterward the inner circles on circular shearing machines of the type shown in Fig. 534. As shown, the lower cutter is in an angular position relatively to the upper, so as to permit the making of as clean a cut on the inside as on the outside. Disks cut in this manner are afterward notched on an automatic notching machine of the type shown in Fig. 535. A plain blanking or notching punch and die are located in the press portion at the left and a circular disk clamped between the two pads of the indexing and revolving the mechanism at the right. The indexing is entirely automatic, the spacing and number of notches in a disk depending on the arrangement of the gearing.

In this machine the adjustment for different diameters is made by simply turning the hand-wheel shown. The adjustment for different numbers of notches is effected by means of the change gears shown, instead of a pawl and index-plate device as is usually employed. Each set of gears can be arranged to answer for three different numbers of notches. The index feed is effected by means of a "Geneve" stop movement; but absolute correct indexing is assured by the use of a positive cam-actuated locking device for the indexing arbor.

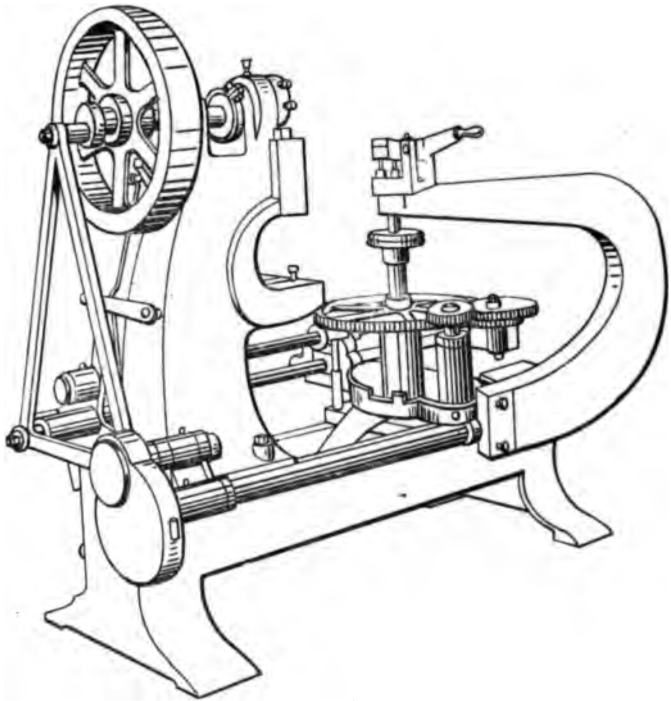


FIG. 535.

In connection with the punch and die used in a machine of this type a spring stripper is used, so as to leave a clear space above the die; making it easier to introduce a new disk, and at the same time provide for holding the disk under pressure when the notch is being punched. This, consequently, obviates the necessity of using a clamping plate over the centre of the disk.

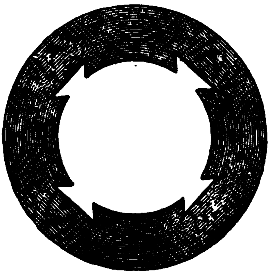


FIG. 536.

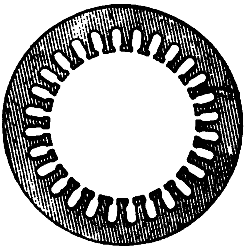


FIG. 537.

When disks of the polyphase motor type, having holes or notches punched in the inner periphery, are required to be notched in a machine of this type, it is necessary to do the notching before the large inner circle is removed, as its surface is needed for carrying the disks in notching. In such disks one or two small holes are previously punched in that portion of them that is afterward cut away, in order to serve as guides in the notching and centre-hole punching operations.

The kind of disks which are of moderate diameter and most frequently required in large quantities are those used for street-car motors. To produce them powerful power-presses are used. These presses are equipped with dies so constructed and arranged that the inside of the disk with its key-slot, and the outside with its notches, are cut simultaneously at one stroke, as shown in

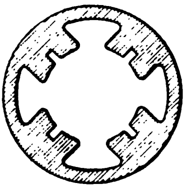


FIG. 538.

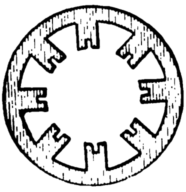


FIG. 539.

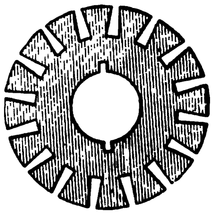


FIG. 540.

Fig. 540. This method constitutes the quickest, most accurate, and economical way of manufacturing armature disks in large quantities. The presses in which such dies as are necessary for such work are used, are provided with knock-out attachments which discharge the scrap and the disks so that they lie loosely on top of the dies, thus allowing of their easy removal.

In regard to the power-presses used for disk punching, it may be stated that the requirements of armatures for electric work have led to the construction of presses which differ in points from those used for other styles of sheet-metal working. As it is always essential to have the outside and inside exactly concentric, so that all notches in the disks shall coincide perfectly with one another when assembled in "cores," it has been found best to adopt dies which, by being cut simultaneously, eliminate the inaccuracies which are wellnigh unavoidable when the cutting is done in two or more operations. In many cases, the notches and key-seats are also punched at the same time. To accomplish these results in one operation, dies of great accuracy are

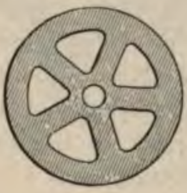


FIG. 541.

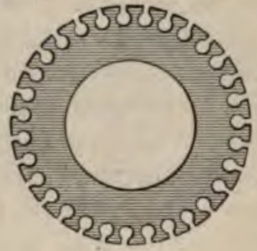


FIG. 542.

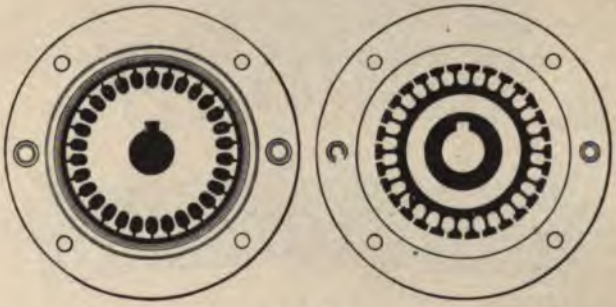


FIG. 543.

required, which, in addition to the cutting parts, must be equipped with "knock-out" pads that will automatically deliver the punched disks and scrap from within the dies. The dies used in these methods of producing the disks are known as "compound dies," and are usually built up in sections which have been hardened, ground, and lapped to size. However, not infrequently, they are made in the usual manner, but the results are not so accurate. These compound dies are very expensive, costing all the way from $150 to $1,000 each. Fig. 543 shows plans of a compound punch and die. As a rule these compound dies are used in presses provided with upper and lower die knock-outs, thus obviating the necessity of the strippers in the dies. The die sections are located in a steel casting. The rings are of tool steel, carefully and accurately worked out, hardened and ground to size, while the remaining ones are left soft. The dark sections in the figure indicate the cutting parts.

As the installation of the above-described method entails a great deal of expense and can be adopted economically only where disks are required in large, steady quantities, it is at once apparent that the dies would be too costly to use for producing disks in small lots. For this reason another method is in vogue. This method consists of cutting out simultaneously the plain outside and the hole, as shown in Fig. 536, and then punching the notches on a notching press. By this method a perfectly concentric blank is produced ready to be notched. As by this method the outside notches are cut separately, the power of the

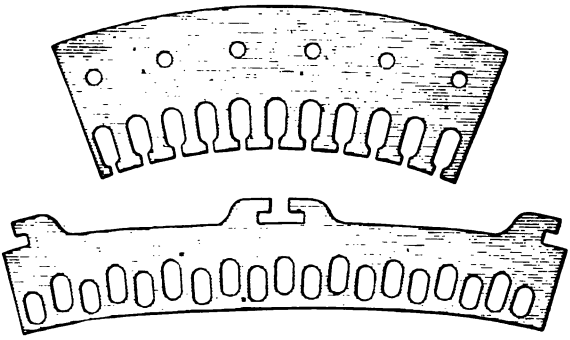


FIG. 544.

presses in which the work is done is equal to much larger diameters than those used in the method before described.

In producing very large disks there is a great deal of scrap, but this scrap is prevented from going to waste altogether by being worked over into disks of smaller size. From the inside scrap, the projections corresponding to the key notches are removed by forcing the disk through a circular trimming die which punches the centre hole at the same time, and thus no great waste of stock is entailed.

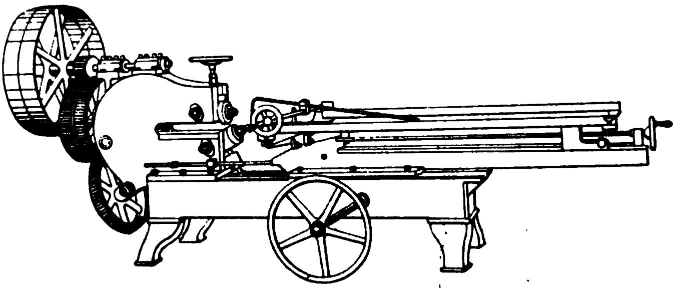


FIG. 545.

In manufacturing armature segments in very large quantities the outside and the holes are usually cut simultaneously in dies in which the stripping of the scrap and the segments from them is entirely automatic, for both the upper and lower sections. A press specially designed and used for this class of work is shown, equipped with proper tools, in Fig. 547. The cutting of sections and segments complete with dovetails, and all notches and holes up to $35\frac{3}{4}$ inches long, can be done on a press of this sort. However, most segments of large size are first punched plain and the notching and perforating are done in succeeding operations.

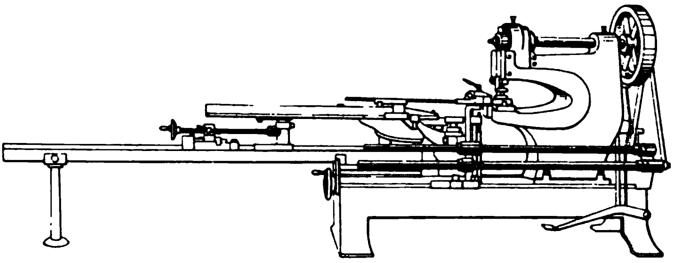


FIG. 546.

When the plain segment blanks are not produced in dies, a circular shear of the same type as that used for disk cutting is used; it being equipped with a segment-cutting attachment, as shown in Fig. 545.

In Fig. 546 we have a side view of an armature-segment notching press. The segment-notching attachment on this machine allows of handling segments having a radius of from 36 to 96 inches and up to 36 inches in length. The manner in which the segments are notched is as follows: The segment to be notched is clamped in a holder at the forward end of a long radius bar, and is traversed across the die face by means of an indexing mechanism and change gears similar to those on the regular disk notching press; when the segment is notched all around the outside or inner edge as required, the press stops automatically. After the operator releases a hand lever the segment may be returned to its original position and removed from the press.

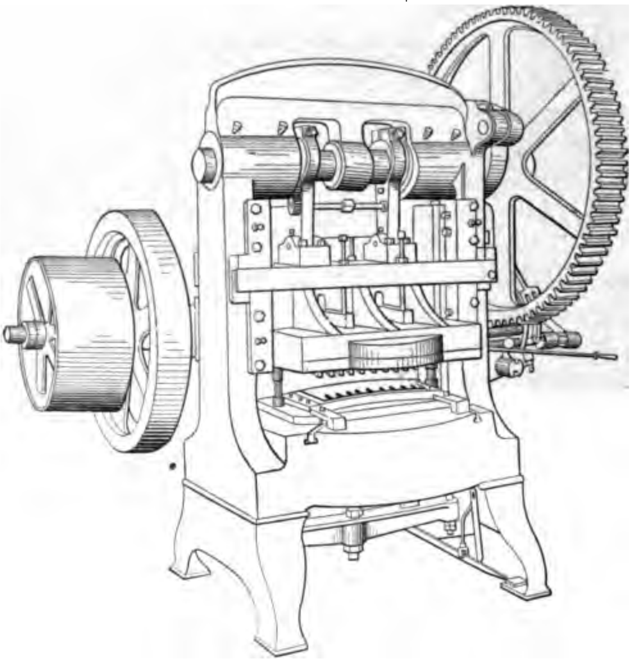


FIG. 547.

CHAPTER XXVIII.

The Manufacture of Accurate Sheet-Metal Parts in the Sub-Press.

THE SUB-PRESS.

THE great increase in the manufacture of innumerable small machines of precision which are made up almost entirely of sheet-metal parts, together with the increasing demand for cheap but accurate watches, clocks, time recorders, meters, cyclometers, and other articles, the utility of which depends entirely upon their precision, has created a demand for accurate presses, dies,

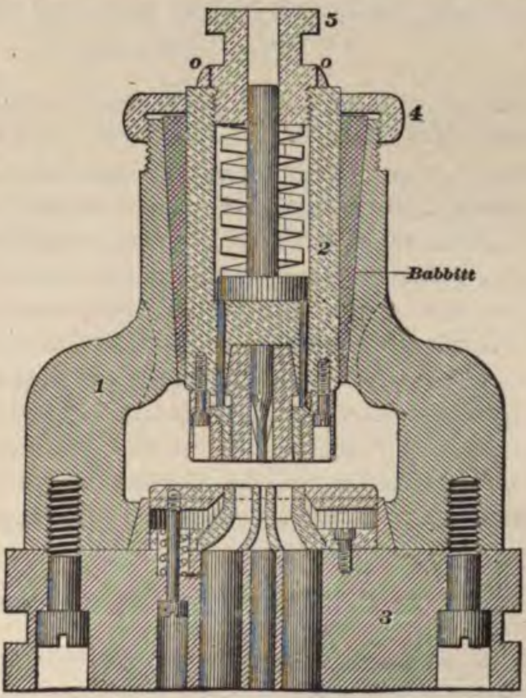


FIG. 548.

feeding devices, and automatic arrangements with which to produce sheet-metal parts in endless repetition with their complete interchangeability assured. For the production of such parts, dies of great accuracy, together with feeding devices which are positive in action, and the sub-press are necessary.

Sub-presses are distinctly different from the other machines which are used for the usual or ordinary lines of sheet-metal work, in that they are made so as to form component parts of the dies, and that they are used almost exclusively for the delicate dies which are required in the economic manufacture of parts of the kind used in the machines, devices, etc., enumerated above.

UTILITY OF THE SUB-PRESS NOT GENERALLY UNDERSTOOD.

Notwithstanding the extensive use to which the sub-press and its accurately made dies have been put, its use and the making of the dies for it are not understood by superintendents, foremen, and tool-makers of sheet-metal goods establishments as they should be. Thus the more extensive use of these tools has been interdicted. Were the case otherwise, and the utility of the sub-press and the making of its dies more generally understood, there would be less worry and more satisfaction in the accomplishment of results which, in many establishments, are at present being attained by means which are now obsolete. In view of this state of affairs I feel that complete descriptions of the sub-press, and how to use it and its dies, will be of great value to all engaged in the manufacture of accurate sheet-metal parts, articles, or devices.

PRINCIPAL USE OF THE SUB-PRESS.

The principal use to which the sub-press is put, is for the manufacture of sheet-metal parts which, because of their unusual accuracy, have to be produced in dies which cut the outside and the inside, as well as any perforations, simultaneously, or at least within the one compound die. By the use of the sub-press and its accurate dies the finest [illegible] may be accomplished with ease, as the dies may always be kept finely adjusted for the work; while the enlinement will be perfect, and thus the possibility of shearing will be entirely eliminated.

COST VS. LONGEVITY OF THE SUB-PRESS.

In regard to the cost of a sub-press and a pair of dies for producing an intricate sheet-metal part, the first outlay is considerable; but then this is really all the cost, as the construction of the press is such that no damage can be done to it while it is being set up or run in the power-press; while the dies for it require but little repairs outside of an occasional grinding of the faces. When it is stated that from 50,000 to 100,000 perfectly interchangeable blanks may be cut and pierced in a sub-press without grinding the punch and die faces, the accuracy and longevity of the tools may be imagined.

HOW TO CONSTRUCT A SUB-PRESS.

In order to be able to construct a sub-press or a set of dies for it the tool-maker must be both skilled and accurate, and must use great judgment; possessing these qualities he may, by carefully digesting the following described methods, be sure of success.

Fig. 548 shows in vertical section and Fig. 549 in plan, a sub-press such as is used in all watch, meter, and cyclometer factories. The sub-press consists of the stand 1, the plunger 2, the base 3, the nut 4, to tighten the babbit lining, and the hook nut 5, which connects the power-press plunger with the plunger 2 of the sub-press. The stand 1 is the first part machined. It is faced and bored on the bottom, and then the barrel is faced and recessed to suit a flange by means of which the plunger 2 is centred at one end for babbitting. The stand is then ready to be drilled and tapped for the fillister head-screws, by means of which it is fastened to the base. These screws are also used to fasten the stand to a special lathe-chuck, by means of which it is bored 3 degrees, taper-faced on the other end, and then turned for the adjusting nut, but not threaded until the stand has been babbitted. The stand having been bored it is then set up in the shaper or keysetter, and four grooves are planed in the inside, parallel with the taper, to prevent the babbitt lining from turning.

We now rough-turn the plunger 2, back-rest it, and then bore it for the punch piston; after which it can be threaded for the nut 5. This nut should be made of machinery steel, and have two flats milled on it at *o o*, so as to be able to remove it from the plunger. With this nut well screwed down the plunger should be turned to within about .005 inch of the finish size, and then finished by grinding, making sure to have it perfectly parallel; after which it should be placed in the miller vice, and four grooves milled in it, being sure to have the miller vice exactly in line; if the vice is slightly "out" a twisting motion will occur in the plunger when in operation in the press, and this will, of course, spoil the dies. Now we draw-file the plunger, using No. 2 emery stick, which will give better results than a file, and then all is ready for the babbitting. We get the babbit at the right heat, pour it, and allow it to rise about $\frac{1}{8}$ inch above the top of the stand.

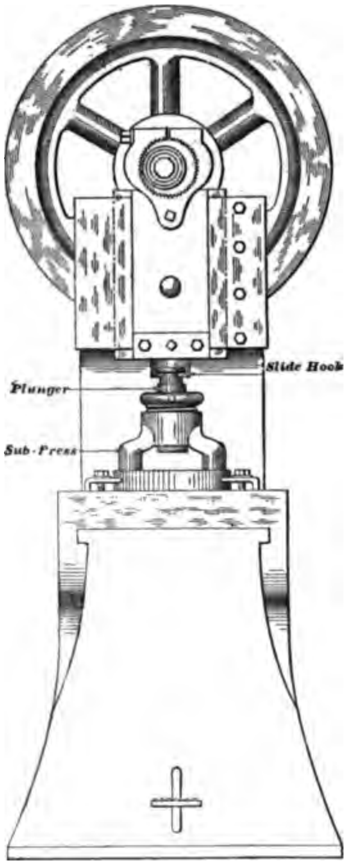


FIG. 549.

As soon as the stand has cooled enough to handle, the plunger should be forced down far enough to allow the babbitt to be faced and squared off on the end, and the thread cut on the end of the stand or nut 4. Now remove the plunger from the stand, and locate the stand in the lathe again; then cut a spiral oil groove of about 1-inch pitch in the babbitt lining. The stand

and plunger should now be secured in the power-press, and pumped, using plenty of oil, and tightening down the nut occasionally so as to get a good bearing. It must be watched at this stage, in order that excessive friction may not heat the babbitt lining sufficient to cause it to swell, and thus destroy the stand. Now reface the stand in the lathe, and face the bottom and bore the seat about 2 degrees taper to fit over the taper boss on the base. The plunger may now be removed from the stand, back-rested, and recessed for the dies. The base can then be located on the face-plate of a lathe—having previously planed the bottom—and the boss turned 3 degrees taper to suit the stand; also recess it for the dies and lower stripper, after which it can be drilled and counter-bored, and then doweled to secure the perfect alignment of the two sections.

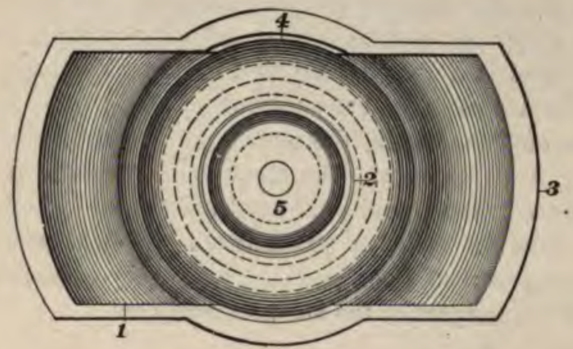


FIG. 550.

SETTING AND WORKING A SUB-PRESS.

The sub-press can be worked in almost any power-press of suitable space. However, usually, a special press is used for the purpose, as a short stroke and a stiff arch-framed press best meet the requirements; Fig. 549 shows a press of this kind.

To set a sub-press, simply slip it into place, as shown in Fig. 549, by sliding the steel neck of the plunger into the press-slide hook, and then locate the hold-drawn clamps into their places and tighten the screws or nuts, thus fastening the sub-press firmly to the bed of the power-press or bolster plate. The dies may now be set and all is ready to proceed with the punching. The changing of a sub-press is very quickly done, as no special skill is required. There are several different styles of sub-press frames; the most common is the round barred-arch shape. An overhang pattern is often used. For the very largest work, such as clock or time-register frame backs, a four-pillar sub-press, which cuts quite large blanks from stock as thick as $\frac{3}{16}$ inch, is used. The manner in which the punching in a sub-press is done must not be confounded with ordinary punching, as it is done in a different manner. As a rule three or more operations are performed at one stroke of the press—that is, cutting the outside, cutting the centre, perforating the blank, and lettering it all at once. The stock to be punched is securely held between the stripper plates and pads; thus the die is compound; thus the metal is straightened and held perfectly flat while being worked upon, and each and every piece produced is an exact counterpart of the one previously cut.

ACTION OF THE DIES—FEEDING OF THE METAL.

In the production of the most accurate classes of work in the sub-press, the punch does not enter the die proper, but descends within a shade of its face, thus parting the blank from the stock, and no more; the strippers flatten its edges out square. It must be understood, though, that the die and punch faces must be perfectly flat and without any shear in order for the work to be produced accurately; for this reason a stiff, well-made press is required. Because of constructing the dies in this manner their longevity is greatly extended, as the punches merely pass through the comparatively soft stock and not in and out of the hardened dies, which would shear and wear them quite rapidly. Never, under any circumstances, allow the punches to enter the dies, as this will spoil the tools in a short time.

As the sub-press is a small, convenient machine in itself, with its dies and punches always in perfect alignment, with no possibility of fitting out of order, it is always set ready for work and all chances of bad or inaccurate work are eliminated. While the first cost of this little machine is large, in the long run it is the cheapest die that can be devised for the accurate and rapid production of perfectly interchangeable sheet-metal parts. It is this little tool that has made possible the manufacture of the "dollar watch."

Roll feeds, or other automatic feeding appliances, are often added to the presses in which these sub-press tools are used. As the articles cut are forced back into their place in the stock from which they were punched by the strippers in the dies, the metal stock is kept straight and it is punched and accurately fed along under the dies at a very high speed, from 75 to 130 punchings per minute being produced.

CHAPTER XXIX.

Engraving, Sinking, Constructing, and Using Dies for Medals, Jewelry, Coins, and Art Goods.

WORKMAN VS. ARTIST.

THE cutting and engraving of steel dies for the embossing of medals, jewelry, and fine sheet-metal work is an art by itself—an art which, besides requiring mechanical skill and a knowledge of the use of metal-working tools, requires a natural talent for that kind of work and the possession of that artistic ability that comes from the love of things beautiful. Without that ability the die-sinker is merely a workman, and will be incapable of originality: it is the talent that makes the artist. However, to those who are already skilled in the art of die-making and who possess to a certain extent the ability to duplicate designs, this chapter will prove greatly instructive; while to those less generously endowed the information contained herein will help them to progress further.

ENGRAVING A HOB FOR SINKING A MEDAL DIE.

In making the dies for medals, etc., the most approved practice is as follows: Taking a blank ready to be cut, Fig. 551, we grind the face dead smooth and then either copper it with a solution of sulphate of copper or give it a thin coat of zinc white and allow it to dry. We sketch the medallion portion on this surface, as in Fig. 552, and cut away to the necessary depth all the outer sections until a perfect silhouette of the figure is exposed, as in Fig. 553. After this the coarser details are cut in, using small chisels, riffles, and gravers, and boldly rounding all portions which are to appear thus, as shown in Fig. 554. The last and most particular part of the work is to engrave and chase in the fine artistic details until the work appears finished, as in

Fig. 555. The "hob" for sinking the die for the face of the medal is thus made.

MAKING DIES FOR EMBOSSING JEWELRY.

In the making of dies for the embossing of jewelry the usual practice consists of working out the sample first to the shape required, after which it should be soldered to the end of the piece of steel which is to form the punch. These pieces of steel are usually kept on hand and are turned to 1⅛ inches diameter and are about 5 inches long, with the small end bevelled to a size just large enough to cover the sample. After the sample has been soldered to the end of the punch blank the outline of the templet is carefully and accurately worked out on the end of the punch by the best means available; the bench miller will prove the best means to adopt for doing this part of the work. Carry out the outline to a distance of about $\frac{3}{32}$ inch from the face of the punch; then take the punch to the shaper and carry the shape up the length of the punch; tapering it to run out about 1½ inches from the face. After this carefully file and finish all points round, so that the end of the punch will have the perfect outline of the sample. The sample may now be removed and the face of the punch shaped as the finished article is to appear.

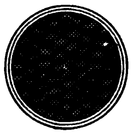


FIG. 551.

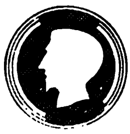


FIG. 552.

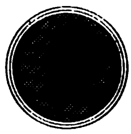


FIG. 553.

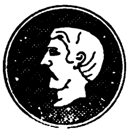


FIG. 554.

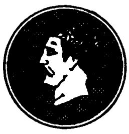


FIG. 555.

This shaping requires a little exercise of the artist's talent, but it is not very difficult if gone at with a little thought and system. The systematic method would be to coat the end of the punch with copperas solution, and scribe a line completely around the punch a distance from the end face equal to the thickness of the finished article.

The dies are usually made of round annealed stock, turned to 1½ inches diameter, the ends faced to about ⅞ inch thick, and the face into which the impression is to be struck finished to a very high polish. Not the slightest scratch is permissible upon the face of either punch or die. This being done, take the punch—which we will now call "master" punch—and the die blank, to either a screw-press or drop-press, set both in their respective places, and when all is in readiness, carefully clean both and oil very slightly with oily fingers. All being firmly fixed in position, the impression is now made. If a screw-press is used a few strong blows will be necessary, and if a drop-press estimate about the proper height from which to drop the weight with the surface to annealed piece, which will soon teach one about how much is necessary to strike a given depth. Raise the weight and let fall, catching the weight before a second blow can be struck. The result of this will be a clean-cut impression, with the original polish of surface almost perfectly preserved but carried down into the blank. Of course the metal will be thrown up around the impression, and this can be faced off in either a lathe or a shaper, since it is necessary to strike a little deeper than required because of the edges being rounded. The die is now marked, etc., and hardened, using something to insure its coming out of this process clean, and then the impression is polished out. It is very necessary for work of this kind that the dies, etc., be highly polished, and especially so when working gold-filled stock, for the smoother the work comes from these dies, the less buffing will be necessary to bring it to a finish.

For the high finish, either Vienna lime or fulminate of iron will give excellent results. Chuck a round stick—orange wood—in a speed-lathe or drill-press. Shape the end with a file while running, and use either of these preparations with water. The Vienna lime is cleaner, fulminate of iron gives the most satisfactory results. We now have a die ready for business, and when this becomes worn large from use, which it surely will do in time, another die can be struck from our master punch.

After a punch has been found to give the results sought for, it is a very good plan to strike off several dies at one time, especially if manufacturing anything like this in large quantities, as there is a gritty surface to annealed pieces which will soon wear out a die, and the form of the piece being changed, will, in a greater or lesser degree, affect subsequent operations. It is a good plan also to strike off one die deeper than is in regular use, finish, and reserve as a master die. This would then make it possible to reproduce the punch also if by accident or otherwise it became damaged or lost.

To produce a punch from the master die we must, of course, use an annealed blank turned up as before and shaped to the impression in the die. This can well be done by laying out the outlines on the end of the punch blank, shape it accordingly in the bench miller, and file it to about the desired shape. Place the master die and punch blank into the die, though not hard. Now remove the punch and ease off all spots showing contact. Replace punch blank and repeat until nearly the exact form has been taken, then ease off the sides slightly, polish highly, and return to the press for a finishing blow. The object of this is to work the punch nearly to shape, and to fit the die so that in the finishing blow the first contact will be in the bottom of the impression. The metal seems to flow into the die better where contact is at first, and should there be a scratch or other sharp indentation, it cannot be rounded out. It is also interesting to note that if a drop of oil gets pocketed in the bottom, this oil will prevent the die being filled out, no matter what pressure is exerted, so that the rule seems to be for either the punch or the die: "Let there be no scratches or dents in either surface; polish highly; keep the surfaces clean from grit, etc., and oiled but slightly with slightly oiled fingers, and rubbed on at that." Finish the taper part of the punch in the shaper and vice, as already explained. Polish, harden, and finish as usual.

Quite contrary to what might be expected by many, sinking small dies in this manner does not induce strains sufficient to be of any serious consequence, and I dare say that with annealed steel there is no more chance of loss than by the method of first heating before striking the impression. In fact, an experienced man almost never loses a die.

When not in use the master punch and master die should be coated with vaseline and stored away in a vault or other safe place. If preferred, these tools can be packed in powdered lime, same as polished spring wire is packed, to preserve the polish.

CHASING THIMBLE, CANE, WHIP, AND UMBRELLA MOUNTINGS.

The small indentations on the end of a thimble, cane, whip, and umbrella mountings, are embossed with knuel wheels where the design will permit. Very fine work is hand-chased, which is performed by filling the articles with lead and afterward driving the thin metal into the lead with chasing tools, the latter being a small, blunt chisel of proper shape to fit the designs or ornaments wanted.

MODELING INTRICATE DIE PATTERNS.

The modeling of intricate die patterns is accomplished in different ways, according to the nature of the work: carving in wood, moulding in plaster, moulding from "modeller's wax," or moulding in gelatin. The once most common method, but now wellnigh obsolete, was that of carving in wood. For large, bold designs the plaster cast is the best. First a rough outline of the work is formed from freshly mixed plaster. After this has set it is cut or carved into the desired form by keeping it moist and using sharp wooden or brass tools; steel tools will not do, as they rust rapidly. In some cases modellers make their first model of clay, then make a plaster or gelatin mould from this by casting; and lastly a reproduction of the original model from this cast.

GELATIN MOULDS.

When a clay model has been made and it is designed to reproduce in gelatin, soak the best white glue in cold water for twenty-four hours, drain off all the water, and melt the soaked glue in a water-jacketed kettle, bringing it to the thickness which will give it the consistency of soft-rubber when cold. To prevent the gelatin fr [illegible] ng, moisten the model with a mixture of common soap and lard oil. Pour the glue upon the model, the latter being incased in a lead or board box; allow the mould to cool for about twelve hours, and then separate the cast from the model by gently rapping around the edges of it. If the model has two surfaces from which casts are to be made, a thread should be attached to the back and extended out of the mould at both ends, so that it may be used for cutting open the mould and removing the model after the mould has cooled.

Another good recipe for a gelatin mould is the following: Dissolve 20 parts of fine gelatin in 100 parts of hot water, and add one-half part of tannin and the same amount of rock candy. A mould made of glue or gelatin only will become more durable if a solution of bichromate of potash and water is poured over it and the mould afterward exposed to the sun. Use one part of bichromate to ten parts of water. Always remember to oil all models before covering them with glue or gelatin, otherwise you will fail to secure a good mould and may warp the model.

USE OF "MODELLER'S WAX."

To make impressions of dies in which the designs are very elaborate, or composed of very fine lines and curves, use "modeller's wax." To make this wax, take two parts of beeswax to one part of bayberry wax; dissolve and mix well and then spread it over the face of the die while warm, first moistening the face of the die with strong soap water to prevent sticking. To secure an impression of a large, bold design, use "dentist's plaster," mixing it with water until about as thick as molasses. It will be necessary to work fast, as the plaster will set quickly. Wipe the face of the die with lard oil and common soap solution and then spread the plaster over the die, running it from end to end. After the plaster has set, heat the die slightly and lay it aside for about twenty minutes, after which rap the edges of the die until the impression separates from it. In pouring the plaster, allowing it to flow from side to side will prevent the formation of air bubbles in the depressions. The further exclusion of air may be ensured by paddling or churning the plaster. As plaster shrinks considerably in drying, it will be necessary to remove the cast from the model as soon as it becomes dry.

As a rule, no matter how carefully plaster casting is done, some defects will appear in the casts, which will have to be patched. Wait until they are thoroughly dry and cold and then scrape the damaged surfaces before patching.

DIES FOR FORMING LARGE ORNAMENTAL ARTICLES.

The dies used for bending and forming large ornamental articles of sheet metal are usually cast iron. Very little work is done on such dies, as they are cast from a carefully prepared model, a fac-simile of the article to be formed, using it as a pattern and working out the die surfaces in a manner similar to the moulding of a pattern in sand. Drop dies are often made in this way, and from these steel dies are dropped, producing them to almost the correct finished shape, thus dispensing with considerable difficult filing, chipping, and graving.

WATER, OR FLUID DIES.

All kinds of hollow ware, such as lamp bodies, artistic toilet cases, match safes such as shown in Fig. 556, silver and Britannia ware and ornamental soft brass shapes, are produced in almost exact reproductions of chased work by means of the "water die," of the type shown in Fig. 557. The "die" consists of a hinged mould having the desired decorations cut on the inside. These moulds are usually cast from carefully carved models and are then finished and touched up until all fine details

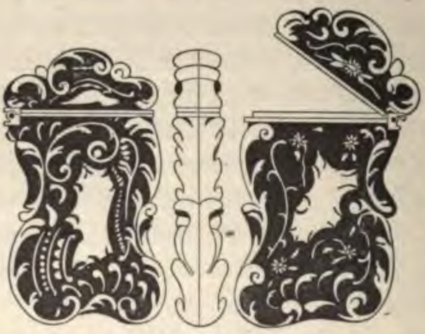


FIG. 556.

are sharp and distinct. A special close-grained cast iron is necessary for such moulds. In use, the mould or "die" is placed under the press and the shell to be swelled and decorated is filled with water and enclosed within it. A plunger fitted to the ram of the press, and fitting the opening in the top of the mould tightly, descends and causes the confined fluid to swell out the metal into the designs in the mould. This is a very economic way of producing decorated hollow ware, and is used almost to the exclusion of all other methods in the large silverware establishments. To produce very plain figures, swells and shapes in soft metals, a piece of soft-rubber is used as a swelling agent, the plunger compressing it on the descent.

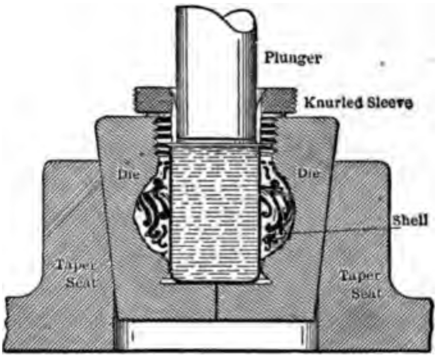


FIG. 557.

COMBINATION DIES FOR EMBOSSED WORK.

Flat, stamped, embossed, or raised sheet-metal articles are usually drawn and stamped up in a first operation and trimmed afterward in a plain trimming-die. Sometimes, when the designs are simple or shallow, the articles are produced in one operation in a combination drawing and embossing die. This is not done as a rule, as the metal is apt to draw and form unequally, and thus the finding of a blank which will draw up perfectly without fins or rough edges is very difficult. Again, the two operations are combined in a progressive die, in which the metal is first stamped and drawn, or *vice versa*, and then fed along and trimmed or blanked out.

MAKING "HOBS" AND SINKING EMBOSSING DIES.

In the making of embossing dies several methods are in vogue. Sometimes both dies are made of steel, or one of steel and one of copper or brass, or one of hard bronze and one of soft brass, while for very large work of bold designs one die is made of cast iron and the other of brass.

In making steel dies for striking up gold, silver, and other valuable metals the first operation consists in carefully annealing the blank which is to form the master die or "hob," and then getting a dead smooth finish on the face, which is then cut and engraved and cut until an exact reproduction of the required design is raised on it. Careful engraving and scraping and giving the proper amount of draft and radius to certain points will be necessary in order to obviate the tendency of the metal to cut apart while being worked; this will be most likely to occur where perpendicular lines or surfaces are presented. After having finished and polished all portions of the design the "hob" may be hardened and drawn to a deep straw temper. We now have a master die or "hob" with which to sink the other die. This "hob" is fitted to the ram of the press or of the drop hammer, whichever it is to be used in.

We now secure another annealed blank, and carefully finish the top and bottom. The master die is secured in the press ram and the blank is placed directly under it. Both faces of the dies are oiled and the master die is forced into the soft face of the blank until a perfect impression of every detail and line in the master die appears. This will require much time and patience, it being necessary to remove the blank several times and cut away the surplus metal thrown up. After the necessary amount of clearance has been given the sunken die, and all points are polished, it can be trimmed, faced and hardened, and tempered. From this die a brass, bronze, or copper "force" is then struck up, which is used in place of the master die in the production of the articles desired. If many dies of the same kind are to be made, such as for coins, a number of sets are sunk from the master die, which is kept for that purpose alone; thus the exact duplication of the design is assured in all the dies. For coins, of course, both dies are of steel. In coin dies the date, which changes from year to year, is stamped in by hand after the impression of the master die or "hob" has been struck.

In using a master die for making impressions the surfaces of the "hob" and the blank should be kept well oiled and the press should be turned very slowly by hand. By keeping the master die for making impressions only, exact duplicates of the worn-out dies may be produced, this being not possible by any other method, as no engraver can exactly duplicate his work by hand.

When making very large steel dies by the method described above it will be found necessary to drop the blank hot. Heat the blank to a cherry red, drop the master die, remove the blank, remove the scale, trim and work out the surplus stock, and then re-drop cold. A perfect impression will be produced in this manner.

BRONZE, BRASS, AND COPPER DIES.

The making of bronze, brass, or copper dies for embossing thin, soft sheet metal in shallow designs and shapes is usually accomplished by first casting from wooden or modelled patterns, and then taking a plaster cast of this, from which a mould or matrix is secured which is carefully scraped and polished. This matrix should be of hard brass or bronze, and the mould of much softer metal, so that it may be forced or dropped into it until a perfect impression appears. It will be found in dies of this kind that the surfaces will wear surprisingly long, as they become hard and tough through the dropping process.

It must always be remembered that in all kinds of engraved dies a feature of great importance in their making is the necessity of cutting deeper all depressions and fissures, so as to leave all the higher portions in a position to be perfectly smooth and polished. This is to prevent the marring or splitting of the embossed side of the article.

For the production of ornamental tinware and other articles in which the ornamentation is coarse and bold, cast-iron dies and brass or hard babbitt moulds are used. These dies require little labor or skill to produce, as the plaster casts or moulds for the dies can be relieved in all deep places, and thus it is not necessary to rout out the brass mould afterward.

When the article required to be embossed is very deep, or where the designs and ornamentation are much raised, it will be necessary to accomplish the embossing with two sets of dies. One set—the first—will have to be supplied with blank-holders and a die having a rough outline of the required design. In this die the metal will be drawn from between the blank-holders and into the die, and a crude impression of the required design will be given it. The article should then be annealed and struck up perfectly in a finishing die. Not infrequently it will be found necessary to use three, or even four, sets of dies to accomplish the desired results in articles which are excessively deep. Trays, salvers, picture frames and plates having ornamental borders not too close to their edges, or circular articles with central raised designs, can be blanked out and stamped or embossed in a combination die in a single-action press, the die being equipped with a spring buffer and a blank-holder ring, or in a double-action die in a double-action press. Shallow shells, boxes or covers, either circular or rectangular in shape, can be blanked, drawn, formed, and embossed or panelled in a triple-action die in a double-action press equipped with an automatic lower punch slide.

To fit the shanks of the embossing dies, upper and lower, or to turn the outsides, clamp the punch or "force" and die together, and then machine as if one piece; thus the perfect alignment of the embossing faces with each other when the die is in use will be assured.

Although for years spoons, forks, and embossed metal handles were produced under the drop hammer, this method has now become almost obsolete, as the improvements in heavy automatic presses and feeding devices for such has made their use for the production of such articles quite general. These machines produce more and better work with less wear on the dies than the drop hammer.

CHAPTER XXX.

The Modern Art of Swaging, Swaging Machines, and the Cold Swaging Process.

THE HAMMER.

MAN'S first tool in shaping metal was the hammer, and with the advancement in appliances, during the centuries, the hammer has continued to hold its place. In modern metal working the hammer is supreme. Its form, it is true, is changed from time to time, but whether the hand tool or the power-driven hammer is considered, the principles underlying its use are still the same.

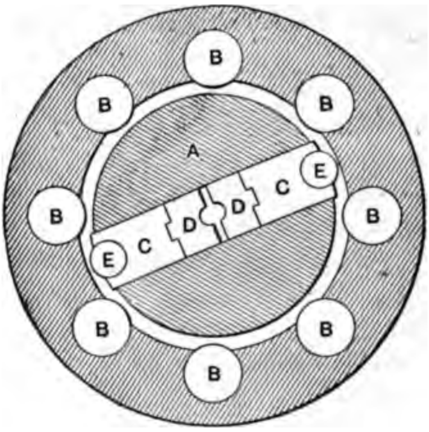


FIG. 558.

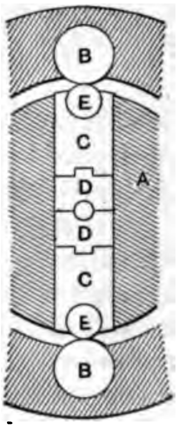


FIG. 559.

The simplicity and effectiveness of the hammer have never been excelled in any other tool, nor even equalled. Whether metal be worked hot or cold, the hammer is the king of tools. Not only does the hammer produce a vast amount of work with a small expenditure of force, but it gives to the metal qualities which can be obtained in no other way. Strength, rigidity, solidity, and increased elasticity are all gained under the hammer, while in the cases of iron and steel a surface hardness is secured which cannot be produced in any other manner.

SWAGING AND HAMMERING.

Swaging, however performed, is only a kind of hammering. The early smiths, it may be supposed, in the very infancy of the race—certainly long before the dawn of history—observed in working the metals with which they were acquainted, that the face of the hammer always left its impression when a blow was struck. Any irregularity in the face of the hammer left a corresponding mark on the metal struck. To this fact, undoubtedly, does modern metal working owe both the art of swaging and the art of die sinking, drop forging, and embossing, for the fundamental principle in each is that of making a special face for the hammer and another for the anvil.

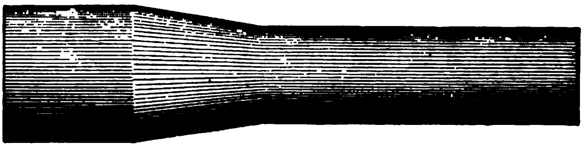


FIG. 560.—Pointing for Drawing.

These special faces for the hammer and the anvil are given the form which it is desired to impress upon the metal, which is to be struck between them. If the piece of metal which is to be worked is, for example, cylindrical in form, the face of each, the hammer and the anvil, is hollowed out, the depression being given the required shape or design. The metal worked between them is then forced by the blows applied into the hollows of the two faces, thus taking on the desired shape.

While it may be supposed that the first swaging, crude though it must have been, was performed between a hammer with a depression in its face and an anvil with a corresponding indentation, it is probable that it was not very long before the early smiths recognized the further fact that a great gain would be made in such work by separating the special faces from the hammer and the anvil, respectively. The hammer, therefore, was again made smooth and heated to be struck against a special piece of metal or false face, to which one-half of the required form had been given. The anvil, instead of being hollowed out according to the design of swaging to be done, was made a large solid block, heavy enough to resist the hardest blows, and provided with means to receive and hold a second special face, the counterpart of that against which the hammer would be struck. What are now known as swaging tools or dies resulted. All that has been accomplished since has related to means of holding tools to be operated, to means of imparting the necessary blows, and to methods of controlling and guiding the work. In the following the matter is a compilation from information kindly furnished the author by the Excelsior Needle Company, of Torrington, Conn., manufacturer of the Dayton swaging machine, and the technical journal *Machinery.*

Strange to say, the ordinary dictionaries, in defining "swage" in the sense of a swaging tool, take into account only one of a pair as commonly used and as above described. One definition, for example, is as follows: "A tool having face of a given shape, the counterpart of which is imparted to the object against which it is forcibly impressed. When used . . . it is either placed on the anvil so as to impress the metal which is laid thereon and struck by the hammer, or the work being laid on the anvil the face of the swage is held upon it and the back of the swage receives the blow." But modern processes of swaging, work the metal on both sides or all around, as in the case of a rod or tube, and for this purpose employ both top and bottom tools.

The use of false faces to the hammer and the anvil, as above set forth, or the use of swaging tools, as the corrected definition describes them, and which are most commonly called "dies," enables a number of blows to be struck in obtaining the required result, which secures an important economy of force, while also rendering the operation less trying to the metal. There is likewise an important gain in the quality of the product. Further, the employment of dies makes possible the use of a machine for imparting the blows, in a way to secure rapidity of action and absolute uniformity of work. The force of the hammer is transmitted through the movable faces or dies without appreciable loss; in fact, with a positive gain in various points of effectiveness.

THE COLD-SWAGING PROCESS.

The swaging process, although extensively used in certain classes of work, is, as a machine shop operation, very little if at all recognized. The success, however, with which this process is employed for certain purposes would seem to indicate that its use might be applied with profit to a great class of work that is at present performed either by hot forging or by machining.

Cold swaging is the act of reducing or forming steel or other material while cold, such as drawing to a point or reducing the diameter of the work. This is performed by a machine which causes the work to be struck a great number of successive blows by a pair of dies of suitable shape to give the required reduction. The process is mainly applied to reducing wires, rods, and tubes, and is the only process by which rolled or plated stock can be reduced without destroying the plating or coating. For this reason it is largely used for jewellers' work, such as forming spectacle templets, fancy pins, and similar pieces. It is also extensively used for pointing rods or tubes which are to be drawn. It will put the best point known to wire drawers, on a rod or piece of wire in a fraction of the time that would be required by any other method, and the same applies to its use on tubing. The millions of needles, bicycle spokes, button hooks, crochet needles, etc., which are turned out annually serve to show some of the possibilities of the swaging process.

The possibilities of the swaging process are almost without limit. The blacksmith through the ages has invented unnumbered applications found in daily use, while the modern machine builder has discovered various means of adapting swaging methods to the rapid and economical production of numerous shapes and forms required in the different trades and industries.

Rod-making in steel and iron, as well as the kindred trade of making bars and axles, is essentially a swaging process. There are modifications in the details of the machinery adapting it to the purpose, but the principle is the same. In the same way the tapering of tubes both large and small is better performed by swaging than by any other process. Modern swaging as a means of reduction supersedes rolling, grinding, milling, turning, and drawing, for the reason that it improves the quality of the material and gives greater uniformity and better surface without waste of stock.

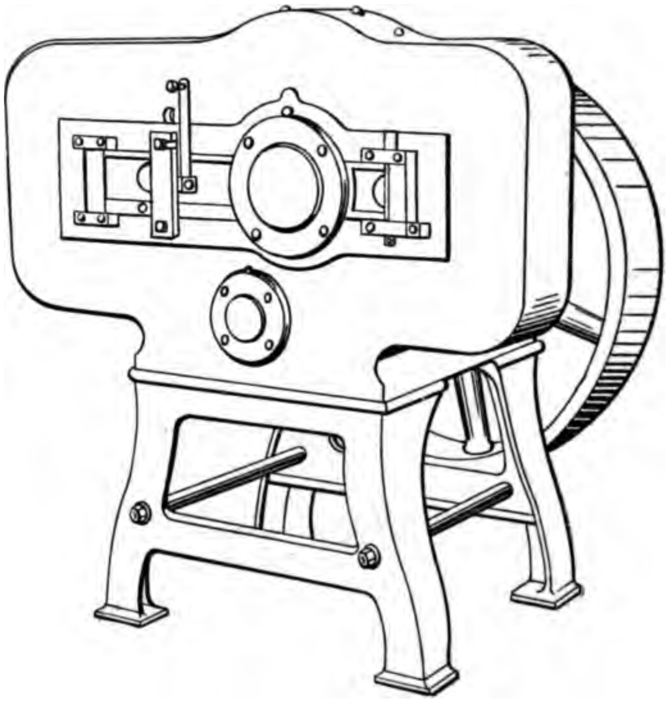
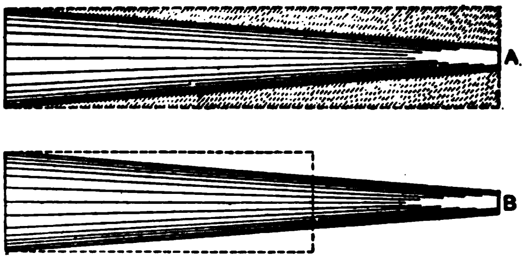


FIG. 561.

One of a pair of tools or dies fastened in an anvil to hold the metal to be worked, and the other sustained above it and adapted to receive the blows of the hammer, constitutes one of the most useful forms of swaging-machines. Substitute for the hand hammer and its swinging blows a series of machine-driven hammers revolving around the pair of dies which are suitably held, and which deliver their blows in pairs upon the ends of the dies, thus forcing them together and against the metal that is between them, and a modern machine is produced the product of which excels in character and value anything that has ever preceded it.

As an illustration of the saving of stock that may be accomplished by the use of this process, we will consider a simple piece of rod which is tapered from full diameter to a small point, as



FIGS. 562 and 563.

shown in Figs. 562 and 563. In view of the piece marked *A*, the dotted lines show the original piece of stock from which it would be made if the work were done on a lathe or screw machine, by

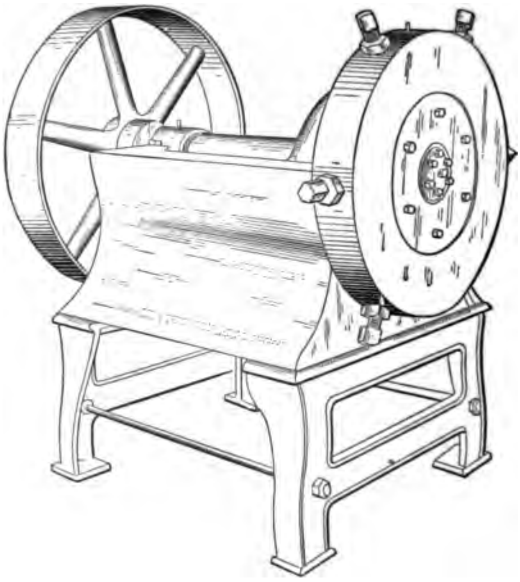


FIG. 564.

the machining process, the dotted section showing the amount of material that would be wasted. In the lower view *B*, the dotted lines show the amount of stock that would be required to produce it by the swaging process, and there would be no waste whatever.

ROTARY SWAGING-MACHINES.

The rotary swaging-machine is now being made by a number of manufacturers, and while the details of the different machines vary in some respects, the principle is the same throughout. Representative machines, made by swaging-machine builders, are shown in Figs. 564 and 565.

The principle of the modern rotary swaging-machine is shown in the line drawing, Figs. 558 and 559. Inside of the head in which the spindle revolves is a set of hardened steel rollers *B B B* which are fitted in recesses in the fixed casting, each of them being free to run on its own axis. The front end of the spindle *A* is large and has a slot across its face in which the hammer blocks slide. These have recesses in their inner ends for holding the dies *d d*,

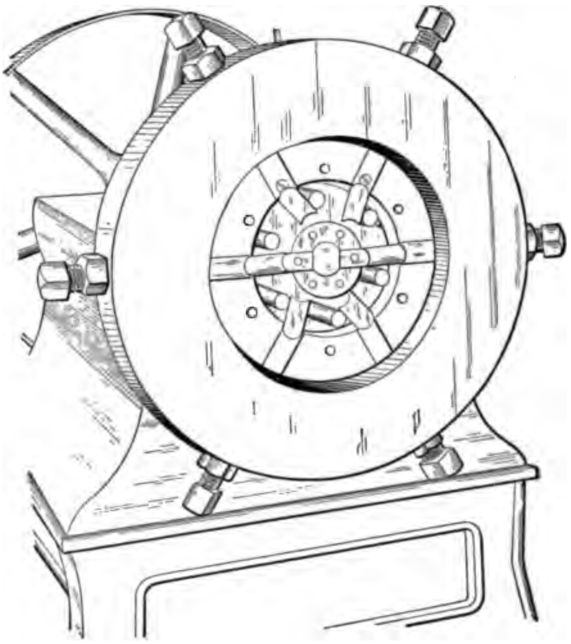
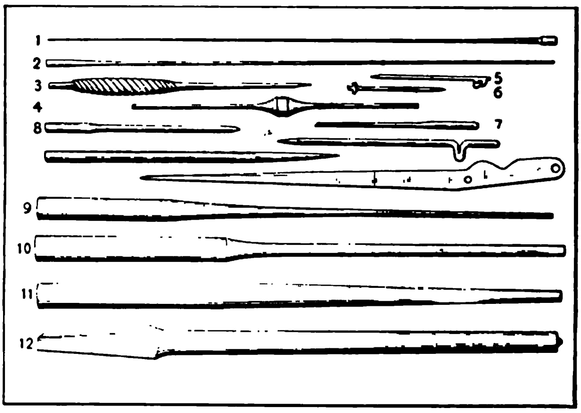


FIG. 565.

and in their outer ends are the rolls *E E* which are free to turn when they come in contact with those in the head. As the spindle revolves and the rolls in the die-blocks are brought into contact with those in the head, the dies are forced together on to the stock. After passing a set of rolls, the dies are thrown apart by the action of centrifugal force, which keeps them separate until the next set of rolls is encountered, when another blow results. The machines are run at a spindle-speed of from 400 to 500 revolutions per minute, and as there are eight rolls in the head, the result is from 3,200 to 4,000 blows of the die per minute. The work in these machines is not rested, as the rotation of the spindle distributes the blow evenly around the circumference of the piece being operated upon. In another type of machine the rollers are replaced by oscillating cams which, when they come in line with the ends of the die-block, form a powerful toggle-joint and bring the dies together with great screws which cause the wedges back of the cams to slide in toward the centre. Some samples of the work done with the rotary machines are shown in Fig. 566.



Samples of Work Done with the Rotary Swaging Machine.'

1-2. Spectacle Temples (Steel)
3. Fancy Pin (Rolled Stock)
4. Ring Body (Plated Stock)
5-6. Pin Tongues (Steel)
7-8. Machine Needles (Steel)
9-10-11. Cotton Machine Spindles (Hard Steel)
12. Bitt (Steel)

FIG. 566.

THE DAYTON SWAGING-MACHINE.'

The "Dayton" swaging-machine, views of which are presented in Figs. 567, 568, 569, and 570, employs dies which are as simple in their essential features as the most primitive swaging tools. These dies, which are adjustable in their relation one to the other, are carried in a slot in the face of a revolving mandrel, and are held between a pair of blocks with rounded ends. On the side of and around the mandrel is an annular rack containing loosely a number of hardened steel rollers. The revolution of the mandrel causes the dies and blocks with rounded ends to pass between successive pairs of opposing rollers which force the dies together. The mandrel is hollow to permit the work to be fed through it. The dies revolve rapidly around the work, which is stationary, while the rack containing the rollers revolves very slowly, being moved only by the slight motion of the rollers during the time of contact with the blocks. Accordingly, the effect of the dies is very evenly distributed about the work.

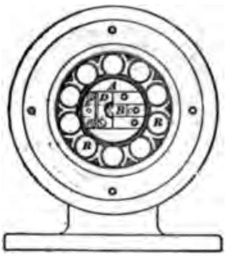


FIG. 567.

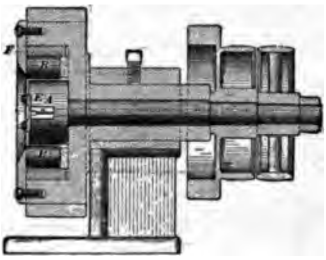


FIG. 568.

The dies are blocks of hardened steel, which have formed upon their inner faces the impression of the shape or the diameter of the work it is desired to produce, with an enlargement or flare at the outer or entering end large enough to allow the unreduced stock to enter. The dies are set up, or what is the same thing, the blocks with rounded ends, or the backs as they are called, are made to project more by placing thin plates of steel between the ends of the dies and the backers. The dies and backers are held in place in the slot in the face of the mandrel by suitable plates.

Referring to the cuts, Fig. 567 shows a face view or front elevation, with plates removed, and Fig. 568 a longitudinal section of one of the smaller sizes of the Dayton swaging-machine. The working parts of the several sizes are essentially the same, so that a description of one will answer for all.

Fig. 569 shows the roll rack, face view, cross-section (one-half), and side elevation (one-half).

Fig. 570 shows the face of the mandrel with the slot for receiving the dies and backers, also a sectional view indicating the central aperture for receiving the work. There are also shown the dies *B* in both side and end views and backers *C*. The plate used for holding the dies in place is shown at *D*.

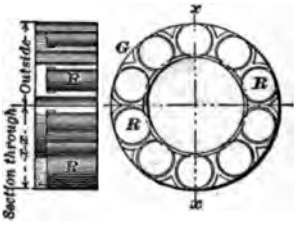


FIG. 569.

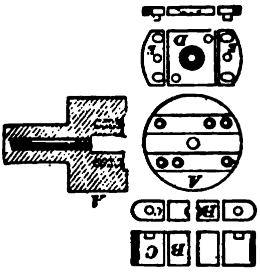


FIG. 570.

Referring again to Fig. 568 it will be seen that the balance wheel, and fast and loose pulleys, are attached to the mandrel at the back, and that the mandrel carrying the dies revolves within the rollers *R*; also that the roll rack, held in place within the cavity of the head of the machine by the plate *F*, is free to revolve as moved by the backers striking the rollers. The head of the machine, which is of cast metal, is reinforced by a wrought-iron ring, shrunk into it upon the outside, and by a hardened steel ring on the inside.

The mandrel is adapted to be run at any rate of speed required by the work being done. With five pairs of rollers in the rack, as shown in Fig. 569, there will be ten closures of the dies to each revolution, varied only by the slight motion imparted to the rack by the backers striking the rollers. Running at a speed of 400 revolutions per minute, therefore, the blows upon, or closure of, the dies will approximate 4,000. The effectiveness of the machine is thus made apparent.

HORIZONTAL SWAGING-MACHINES.

The horizontal swaging-machine was originally designed by Mr. John Henderson, of Waterbury, Conn., and the first machines were built by him. Later, the manufacture was transferred to the Waterbury Machine Company, by whom this type of machine is now manufactured. The horizontal is especially designed for work of a heavy nature, such as is encountered in mills where rods and tubing are manufactured. It is constructed on a principle entirely different from that of the rotary machine. Fig. 571 shows a machine of this type. The round hole at the left, in line with the upper bearing, is the opening where the work is introduced. The centre of this hole marks the place where the dies are split on the vertical line. One-half of the die is backed up directly against the heavy casting of the frame, and the other half, toward the bearing, has a reciprocating motion on the horizontal line. The means by which this motion is obtained will be seen by reference to Fig. 571.

The lower main shaft *A* carries the balance wheel and has a crank of short throw between the bearings, while the upper shaft *B*, of large diameter, has a crank with a throw about six times as great. A connection *C* joins these two cranks; it will turn the upper shaft through but a portion of the circle. If a line be drawn through the centre of this upper shaft, so that it is horizontal when the shaft is in the middle portion of its turn, it will follow that this shaft will have a rocking motion about its centre, and the diameterically opposite points where this line meets the periphery of the shaft on either side will each pass the centre twice for every revolution of the pulley. If, now, a system of

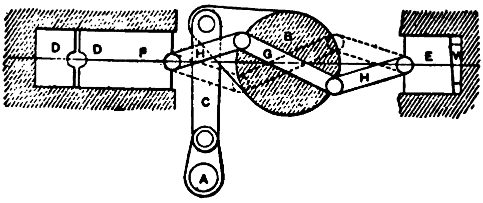


FIG. 571.

horizontal toggles be interposed between the reciprocating block and the frame casting at the right, in which system the middlle block passes through the shaft, it will follow that by the rocking motion of this block the distance between the extreme ends will increase and decrease twice per pulley revolution, or, in other words, the number of blows will be twice the speed of the pulley. A spring, not shown in the cut, is used to separate the dies between the blows.

These machines reduce up to 2⅝ inches in diameter and tubes up to 4 inches, and the amount of reduction ranges from ⅛ to ¼ inch for rods and ⅛ to ½ inch for tubes, depending upon the diameter and nature of the material. Where a much greater reduction is required than can be made by passing the work once through the dies, it has proved a great convenience to use a machine with three sets of dies which gradually decrease in size. This is brought about by lengthening the machine out at the left-hand end for two extra pairs of dies, and as but one pair is in use at a time, motion is transmitted from one set to the other, all having a sliding fit in the opening. The form of the die is a cube, so that four faces may be used as required, the dies being turned around to bring similar half-openings together. When small diameters are required, several sizes can be cut on each face, and the changing from one size to the other is but the work of a moment.

While the machine is principally designed to point rods and tubes for subsequent drawing through dies, it has numerous other uses, such as flattening round stock to a desired shape without waste of material. In this way it has been successfully applied to shaping ends of rods for screw-driver blades, the round rod being merely pushed into the opening and the finished article withdrawn without any fin or waste. Many other operations of a similar nature may be performed, and in this class of work it covers a ground not practicable with any other type of machine.

SOME EFFECTS ON WORK ACCOMPLISHED BY SWAGING.

The work performed by the swaging process is done by pressure rather than by blows. Accordingly, there is a flow and readjustment of the molecules of the swaged metal, the effect of which extends equally throughout the piece in a manner to strengthen it and add other desirable qualities. To perceive the adaptability of the machines to a very wide range of work, from articles of the smallest dimensions up to those of a considerable size, requires only an acquaintance with the principle upon which they operate.

CHAPTER XXXI.

PROCESSES AND METHODS FOR THE WORKING OF ALUMINUM.

ALUMINUM VS. OTHER METALS.

THE innumerable uses to which aluminum has been put during the last few years, and the large variety of articles—from kitchen utensils to drop forgings—now produced from its various alloys, promise that the "beautiful white metal" is destined to be very extensively employed. Sheet aluminum, at least, is replacing the other metals, as experiments have determined that it can be worked as expeditiously and economically as the older commercial sheet metals. It can be worked, when of a proper alloy, as easily as sheet brass, German silver, or tin-plate, and in numerous instances—when the tools have been made correctly and the metal is lubricated properly while working—it can even be worked more cheaply than any of the other sheet metals.

DIFFICULTIES ENCOUNTERED IN WORKING.

The most serious difficulties to be encountered in working aluminum are "hooking-in," clogging and squeaking, in drilling; tearing and "gouging-in," in milling and planing; "jamming" up or blocking of punchings in dies, and consequent breaking of punches; the cohesion of fine particles of aluminum, compressed hard, to the cutting-edges of punches and inside of dies, and on bending or forming dies scratching the aluminum; parting or breaking the metal in drawing it.

PURE METAL VS. ALLOYS.

One thing that a great many mechanics are not aware of is, that aluminum should hardly ever be used in its pure state. Many of those who have experienced difficulties in working the metal have been using the pure metal instead of a suitable alloy.

A majority of the aluminum alloys compare with the pure metal about as brass compares with copper, and as brass can be worked more easily than pure copper so aluminum alloys can be worked more easily than pure aluminum. One has only to gaze at the variety of articles and novelties which may be found in a shop-window or on a department-store counter, and to note their cheapness, to understand that there can be no great difficulty in working the metal into any shape that any sheet metal will flow to.

SECRETS IN THE WORKING OF ALUMINUM.

The two great secrets—that is, if we may term them secrets—in the working of aluminum, either in its pure state or in any of its alloys, is the use of a proper lubricant, and in the proper shape of the cutting-edges of the tools.

GRADES AND ALLOYS OF SHEET ALUMINUM.

There is a great variety of grades and alloys of sheet aluminum on the market, so numerous that no difficulty should be experienced in producing that suitable for any special purpose. Aluminum may be had in much the same variety as sheet brass, or in all degrees of hardness, from dead annealed stock to the pure, stiff, springy aluminum. Next to the pure metal is a hard grade of alloys, ranging from dead soft stock, which will spin, draw, or form up hard and stiff, to the same grade hard rolled. After that comes another set of alloys which are replacing sheet brass in a large variety of kitchen utensils, novelties, parts of instruments, mechanical appliances, and the lithographer's stone. Lastly there is another grade of alloys which has been perfected lately from which great things may be expected, which are beginning to be used for drop-forgings. Experiments have shown that drop-forging can be accomplished with this metal more easily and satisfactorily than with many others, because certain alloys of aluminum can be worked cold.

WORKING THE METAL.

Now about working the metal. In turning, milling, or drilling aluminum in its pure state more difficulty has been experienced than in the press-working of the sheet metal. All these difficulties disappear if the tools are made properly and the right lubricant is used. The tool should be made with lots of top clearance and bottom rake, and instead of the stub point, as used for brass, it should be lengthened out. The top clearance should be sufficient to allow the turnings to free themselves easily and not clog around the point. Lastly the tool should be tempered at a light straw, and stoned to a keen edge.

LUBRICANTS TO USE.

As to the best lubricants to use for the machine operations of turning, milling, or drilling, crude oil is best for milling and kerosene for drilling; while for turning, soap water, and plenty of it, will give grand resuls. A few years ago a large number of small electric cloth-cutting machines were being built under my supervision, the motor cases, brackets, standards, and bases of which were castings of aluminum, all of which had to be machined all over to interchange perfectly. A number of fixtures were constructed for their production, which were described and illustrated by the writer in a series of articles in the columns of the *American Machinist* during September and October, 1900, under the title of "Tools for Interchangeable Work." I had to do a great deal of experimenting to produce the parts to the required degree of finish and interchangeability. All sorts and shapes of cutting tools were tried and different lubricants were used. It was found that drills, counterbores, reamers, centres, and turning tools would work beautifully when lots of clearance was given them, the edges being well hardened and then stoned to a keen edge; that soap water was the best lubricant for drilling, and for large counterboring a cheap grade of vaseline. With the crude oil for a lubricant in milling, butt mills, $\frac{1}{4}$ inch in diameter, were used to take deep, wide cuts without undue strain on the teeth, without the cuttings clogging; and, instead of a coarse, torn texture resulting, a shiny, smooth finish was the pleasant attainment. In one large shop in Brooklyn, which makes specialties of lithographing presses, bronze machines, and bronze lithographing dusting machines, they formerly used large numbers of brass brackets for the grippers on the presses, but now they use aluminum castings.

CUTTING DIES FOR ALUMINUM.

In cutting dies for aluminum there should be at least one degree clearance. If the blank is over $\frac{1}{16}$ inch thick and a smooth, uniform edge and exact size of blank are required, it should be recut or "shaved" in a second die, which should be made straight on the inside cutting edge for not more than the thickness of one block—or two at the most—in order that the die may retain its exact size after re-sharpening. Allow about 0.01 inch on the outside of the blank for shaving to $\frac{1}{8}$ inch of thickness, but if the blanks are of hard aluminum alloy, half that amount will be sufficient.

The cutting-edges of both punch and die should be sharpened very smoothly after grinding with an oil stone.

Lard oil or melted Russian tallow, the best for lubrication, should be used on both sides of the metal.

Punches and dies should be carefully cleaned occasionally of the fine particles of aluminum that will be found adhering to the edges.

DRAWING-DIES FOR ALUMINUM.

In drawing aluminum of a thickness not more than $\frac{3}{32}$ inch and a depth of draw more than $\frac{1}{4}$ inch, to avoid the tearing or wrinkling of the blank it should be held between a ring supported on pins and springs and the face of the punch, rather than between the edge of the forming cavity of the punch and the sides of the forming-block, as is the case in a draw-plate die; but, however it may be held, after it is drawn up first in U-shape—redrawing several times if necessary in ordinary draw-plates and plungers—care must be taken not to employ too fast a speed in the operation, or the work will break at the bottom through too sudden impact.

If the aluminum to be drawn is thicker than $\frac{1}{32}$ inch, it can be drawn direct, without the spring ring mentioned above, to a depth of $\frac{5}{8}$ inch, or even deeper, the exact depth depending largely of course upon the composition of the aluminum alloy, the shape of the article to be produced, the finish on the dies, and the speed of the press.

Aluminum is not a suitable metal to work in compound or sub-press pieces, as the number of pieces of this metal that can be punched out without putting the dies out of commission by clogging and consequent breaking of punches will not be sufficient to pay for the cost of the tools.

DRAWING ALUMINUM SHELLS.

For the drawing of aluminum shells, tools of the same construction as those which are used for the production of brass or tin ones should be used. One peculiarity of aluminum which manifests itself when drawing the metal is that one cannot obtain as great a depth with it in one operation as can be done with brass. This is because the tensile strength of aluminum is somewhat less than that of the other metal. It may, however, be drawn deeper without annealing than any other commercial metal. An article made of brass requiring, say, three or four operations to complete, must usually be annealed after each redrawing operation; conditions, such as the thickness of the stock, depth of draw, etc., determining this. With aluminum, however, if the proper grade is used, it will often be found possible to perform the entire number of operations without annealing at all, or at most once. At the same time a finished shell will be produced which will be equal in every way to one made from sheet brass.

BENDING AND FORMING DIES FOR ALUMINUM.

Bending or forming dies for aluminum should have all the friction parts very smooth and polished in the direction of the draw or bend; that is, the grain of the die and punch should be in the direction in which the metal travels in the die. Lard oil should be used on both sides of the work.

SPINNING ALUMINUM.

In spinning aluminum, best results are obtained by employing a high speed, with a light pressure of the spinning tool, evenly and gradually applied. Aluminum may be stamped under a drop-hammer with about the same weight and momentum as required for silver.

ANNEALING ALUMINUM.

Articles of aluminum may be easily annealed by heating in an ordinary muffle, taking care not to get the temperature too high. The proper annealing heat lies between 650 and 700 degrees Fahr. The best test for the heat is to take a soft pine stick and draw it across the metal. When the wood chars and a black mark is left on the metal, it is sufficiently annealed and is in the proper condition to proceed with the further operations.

POLISHING AND FINISHING ALUMINUM.

Next to the working and machining of aluminum the most important processes lie in the polishing and finishing of it. After the articles have been produced, a fine polish can be given them by first using a rag buff treated with tripoli to cut down with. The high finish can then be attained by using a dry rouge that comes usually in lump form, first grinding it to as fine a powder as possible. The tripoli also should be very finely ground.

For a great many manufactured aluminum articles a frosted surface is desirable. This is usually done by scratch-brushes made of brass crimped wire of, say, No. 31 to No. 34 B. & S. gauge. Three or four rows of bristles will do. To lessen the work of scratch-brushing, the metal may be first cut down with a porpoise-hide wheel and fine Connecticut sand, the sand being fed between the surface of the wheel and the article. By using this latter method first, the skin, pimples, and all surface irregularities are removed, and the scratch-brushing is made easy. When the worked metal is smooth and of good appearance the cutting down with tripoli will be all that is necessary, after which the rouge may be used as described, and the finished surface put on with the scratch-brush. By taking the preliminary precautions the scratch-brushing will frost the metal quickly and uniformly.

Another way of obtaining a similar effect to that of the scratch-brush is by sand-blasting. This is usually done to the sheets before working them, first sand-blasting and then scratch-brushing. The effect remains after the articles have been drawn up, as the metal works in much the same manner as lithograph sheets would, in the working of which, as is well-known, the designs are not marred.

There is still another method for producing a very pretty frosted effect on aluminum. It consists of first sand-blasting and then frosting by "dipping." A great many varieties of finish on aluminum can be obtained by suitable combinations of these treatments.

To secure a pretty mottled effect on aluminum the article should first be polished, then the scratch brush-applied, and then the surface burnished with a soft pine wheel which should be run at a very high rate of speed. By careful manupulation regular or irregular patterns of mottling can be obtained.

The cheapest and most economical way of producing articles with finished surfaces from the sheet is to treat the sheets as follows: After removing all grease and dirt from the metal by dipping in benzin, cleanse in water until the benzin has disappeared, after which the plates may be dipped in a strong solution of caustic soda, or caustic potash, holding them in the solution until they commence to turn black. Then remove the sheets, dip again into water, and then into a solution of concentrated nitric and sulphuric acids. After removing from this last bath, wash the sheets thoroughly in water, and dry in hot sawdust. The finish on the plates can be varied by varying the strength of the caustic solution, or by adding a small quantity of salt to the full-strength solution.

BURNISHING.

For articles which require to be burnished a steel burnisher or a bloodstone will give the best results. When burnishing the use of a mixture of melted vaseline and crude oil as a lubricant, or a solution composed of three tablespoons of borax dissolved in a quart of hot water with a few drops of ammonia, will add to the finish of the work.

ENGRAVING AND CHASING ALUMINUM.

A great deal of engraving is now being done on aluminum, such as on finished picture-frames, cups, trays, book-covers, match-safes and similar articles, and for this work the best lubricant to use on the tools is naphtha or crude oil. A mixture of crude oil and vaseline also is good. However, the naphtha will be found the best, as it will not affect the satiny finish around the edges. Besides the use of a proper lubricant when engraving aluminum, considerable skill is necessary in the making and use of the cutting-tool. A tool made similar to a turning tool for aluminum, finished to a sharp, keen point with lots of clearance, will work excellently.

A property that makes pure aluminum very valuable for many purposes lies in its ability to withstand the action of acids. While the metal is easily affected by alkalies, the strongest acids do not injure it to any noticeable extent—in fact, acid acts on it in much the same manner as on platinum. For parts of apparatus which have to be immersed in strong acids for considerable periods, parts of aluminum will prove highly efficient. One use to which the metal has been put in this respect is for hooks for removing photographic negatives from the acid baths. Acid funnels of aluminum also have proved a boon to many.

SOLDERING ALUMINUM.

The last, but not by any means the least valuable, process in the working and use of aluminum is soldering. To many the difficulties experienced in this line have proven a great detriment to the successful use of the metal for many purposes. The uncertainty as to the best solder to use has been one. There are any number of solders which have proved fairly successful when skill has been employed in using them. The following has proven to be the best in practice for soldering the pure metal or any of its alloys: Fuse together one pound of block tin, four ounces of spelter, two ounces of pure lead, three pounds of phosphor tin. With benzin clean all dirt and grease from the surfaces of the parts to be soldered and then apply the solder with a heated copper "iron." When the melted solder covers the surfaces completely, scratch through it with a wire brush, which will break the oxide and take it up. Spread the solder again with the iron and allow to cool. When it is found necessary to "sweat" aluminum parts together, first clean the surfaces as described for soldering, then heat the parts until the solder flows freely over them, scratch through with the wire brush, wipe with clean waste, and clamp together. A first-class joint will result.

ALUMINUM AS AN ABRASIVE.

Aluminum, despite its metallic character, can be used as an abrasive for sharpening knives. It has the structure of a delicately grained stone, and under friction gives an extremely fine mass which adheres powerfully to steel. Consequently, blades sharpened on aluminum rapidly take a thin, sharp edge which cannot be produced by the best stones. If knives are passed with utmost care over a razor stone, the edge, when magnified 1,000 times, shows irregularity and toughness, while edges produced on aluminum, when submitted to the same examination, appear perfectly straight and smooth.

CHAPTER XXXII.

Hints, Kinks, Ways, and Methods of Use to Tool-makers and Die-makers.

NOTES ON CIRCULAR FORMING TOOLS.

WHEN making circular forming tools always keep the fact in mind that the diameter has much to do with their wearing qualities; and that unless their diameter is proportionate to the diameter of the work satisfactory results will be hard to obtain.

In Fig. 572 are shown two circular tools of 1½ and 2 inches diameter, respectively, both cut out ¼ inch below centre, as they would be if intended to operate on the front side of the machine or at the back side with the work running backward. Although shown in this position, the principle involved is of course the same as though the tools were placed the other side up, the tool-post being bored out above the centre-bore of work spindle, instead of below, as in the case referred to.

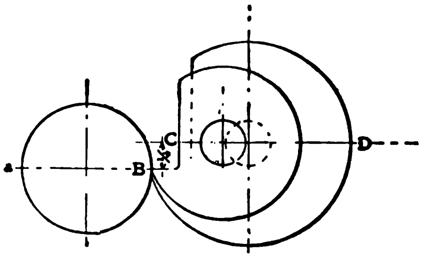


FIG. 572.

Referring to Fig. 572 it is easy to see that the cutting-edge of the larger tool would have much greater endurance than that of the smaller, the rake or clearance of the latter being excessive. This difference of rake in circular cutters must of course increase with the difference in diameter of the cutters, provided the cutting-edges are located at the same distance from centre. The case is similar to that in Fig. 573, where are shown side by side two straight cutting-off tools, the clearance of one ground as at *E* and the other as at *F*. The angle of clearance of *R* is practically the same as that of the larger circular tool in Fig. 574, while that of *F* coincides with that of the smaller tool and shows much less durability than the tool ground as at *E*.

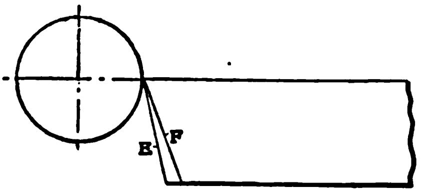


FIG. 573.

It is usually the best practice in making tools for a certain size machine to keep them as closely to one diameter as possible. In the larger machines cut out the tool $\frac{3}{16}$ inch from centre, and of course bore the tool-post a corresponding amount above or below the centre, according to which side up the tool is to be operated. For the smaller machines make the tools of less diameter, cutting them out $\frac{1}{8}$ inch from centre and boring the post to correspond. In Fig. 574 line *A B* represents centre of work, *C D* centre of large cutter, showing the same cut $\frac{3}{16}$ inch below centre, while *C D* represents centre of small cutter and shows the same cut $\frac{1}{8}$ inch below centre. The clearance of both cutters is practically identical.

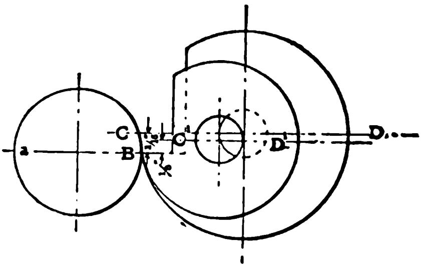


FIG. 574.

A KINK FOR DRAWN WORK.

A sharp corner under a shoulder or flange is often a very desirable thing, and one generally considered impossible in drawn work because of the necessity of a round corner on the die to keep the metal from tearing while being drawn through the die. There is a method, however, of doing this that is quite successful, as shown by the accompanying sketch, and it seems to be about the only way it can be done. The "kink" consists in making the punch a series of steps as per Fig. 575, with round corners instead of a parallel one, as in the usual practice; the steps to be about as far apart as the depth to be drawn; and the difference in diameter of steps to be determined by thickness of stock. The blank, instead of being a round disk, is a washer, the outer edges held not too tightly by the usual pressure ring or plate, and the end of the punch to be a little larger than the hole in the washer. The punch will open the hole to the full diameter of the end and turn the sharp corner of the disk in the most surprising manner. The steps follow each other rapidly, each one enlarging the hole to its own size and carrying the stock down through the die, the last step being the finished size of the interior of work, and the hole in the dies being the outside diameter of same. A die like this needs a press with a good long stroke, depending, of course, upon the character of the work.

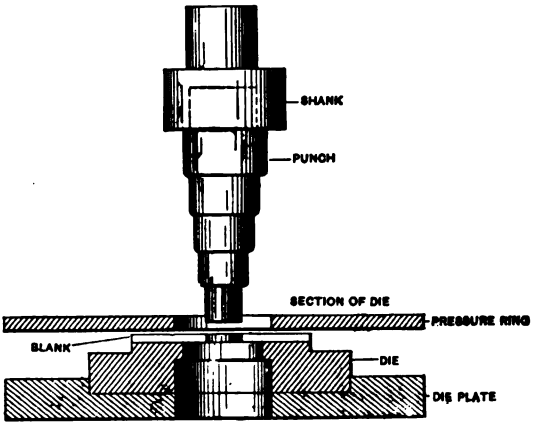
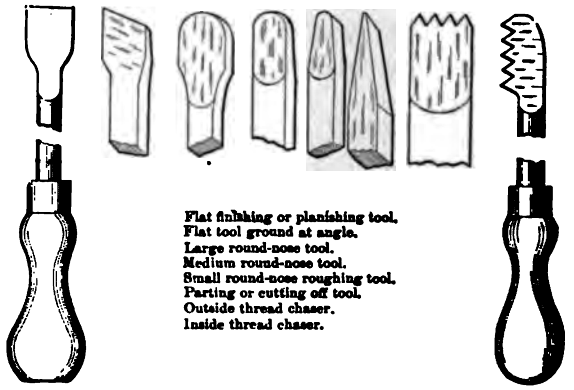


FIG. 575.

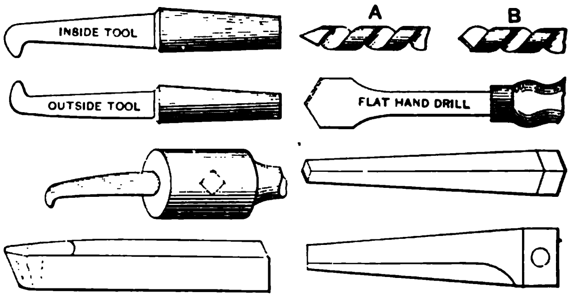
BRASS-WORKING TOOLS AND THEIR USE.

Figs. 576 to 583 illustrate brass-working tools for hand work. No. 576 is a flat planishing tool which is used for finishing and smoothing down flat surfaces, and also convex surfaces. No. 577 is a flat planisher, ground at an angle so as to allow of getting into a corner. Nos. 578 and 579 are for finishing in round corners or roughing concave surfaces. No. 580 is a small round-nose tool which is generally used for roughing out work or getting under the scale of a casting. No. 581 is the proper form of hand cutting-off or parting tool. None of these tools should have any top rake; on the contrary, they should be ground slightly the other way and carefully stoned on an oil stone. Nos. 582 and 583 are hand thread chasers, which are respectively for outside and inside threads.



Flat finishing or planishing tool.
Flat tool ground at angle.
Large round-nose tool.
Medium round-nose tool.
Small round-nose roughing tool.
Parting or cutting off tool.
Outside thread chaser.
Inside thread chaser.

FIGS. 576 to 583.



FIGS. 584 to 591.

The tools shown in Figs. 584 to 591 are for use in the Fox lathe. The hook tools which are used in the back head of the machine closely resemble the regular inside tools, except that the point is turned the other way for outside work. Sometimes a tool-holder similar to that shown with set-screw is used with small inserted cutters. Give these tools no top rake and no difficulty will be encountered in their use.

By grinding a twist drill as indicated at *B* all danger of drawing-in will be avoided; that is, grinding the lips flat for a short distance. On a small drill the whole point may be ground flat to obtain the best results.

The flat hand drill illustrated is the best for rough-boring a hole in a solid piece. A series of such are used for taper holes, the larger being used first and the others following to the proper depth to make about the required taper. This is then reamed out to the exact taper with various tools. A flat reamer is often employed with good results, especially for roughing. For finishing it is very apt to chatter unless packed on each side with a piece of hard wood of about the right shape to conform to the hole. Sometimes a reamer with a single large flute, as shown, is used with good results. It is relieved nearly all the way around. For finishing, it is hard to beat the old reliable square reamer as shown at 590. This reams a nice smooth hole as it fills up with chips enough to prevent chattering, and it starts well if carefully ground and honed on an oil stone.

GRINDING TWIST DRILLS FOR CUTTING A SECTION OF A HOLE.

In order to drill holes in which part of the drill has to cut a section of a hole as shown in the sketches Figs. 592 and 593 the drill should be ground as shown in Fig. 593. It will then be found as easy to drill the holes straight as if drilling a full hole.

To start the drill, use an ordinary drill, drilling just deep enough to enter the blades of the drill as ground in Fig. 593; or a jig may be used to guide the drill in starting.

TURNING AND TRUING RUBBER.

The medium-hard compositions of rubber work very nicely with a diamond-point tool, ground a little round on the point and given a sharp rake. The tool should be hardened very hard, as there is sufficient fine grit in the rubber to wear the edge badly. The speed is governed by the ability of the tool to stand up to the work, and is slower in proportion as the rubber is harder.

Soft-rubber articles cannot be cut satisfactorily with any kind of a tool; the best and quickest way is to grind them down. In fact, grinding makes the most satisfactory job, whether the rubber is hard or soft.

The grinding may be done in a lathe, using an overhead drum for driving the wheel and bolting the wheel arbor to the tool-post block.

In plants where electricity can be had a small direct-connected motor, with flexible cord and plug, makes the most convenient drive, as it is readily detached and put away when not in use, leaving plenty of head room over the machine, a quite important detail in shops where most of this work is done, and where one or two lathes have to do all the work, large and small.

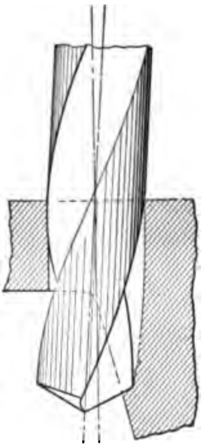


FIG. 592.

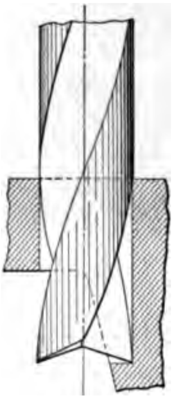


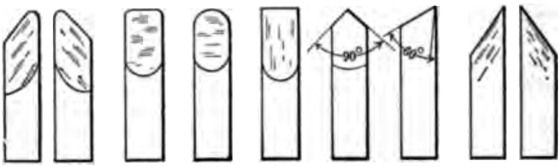
FIG. 593.

The best results are obtained by using cast-iron disks for wheels, 8 to 10 inches in diameter and 1¼ inches thick, with a groove 1 inch wide and ⅛ inch deep turned in the face. This groove is filled with strong twine, laid on tight in hot glue and then covered with several coats of glue and No. 40 emery. These wheels are to run dry.

PATENT TOOL-HOLDERS.

Figs. 594 to 600 show a complete set of the tools that with a straight tool-holder will accomplish all ordinary lathe work.

In grinding these tools always take them out of the holder, otherwise they will be too heavy and liable to heat when placed against the emery wheel. If the cutter alone is held in the hand it gives timely warning, by becoming too hot to hold comfortably, and is cooled off before it gets hot enough for the temper to be drawn.



FIGS. 594 to 600.

HARD-SOLDERING.

In the operation of hard-soldering, if the action of heat and the nature of the metals in hand are understood, there should be no trouble in obtaining a good sound joint, provided the proper facilities are available. Jewellers, as a rule, are very painstaking in their preparatory work, rubbing borax paste upon slate, exercising great care to avoid touching the joint with the hands, so as to have chemically clean metallic surfaces, etc. This is all correct, theoretically, but some machinist workmen also pay all attention to these details, and yet lose sight of the more important fundamental principles, especially those pertaining to temperature. In a large portion of the hard-soldering to be done in the average shop, the observance of these minor details first referred to would involve considerable trouble. These may be safely ignored to a large extent if the applications of flux, solder, and temperature are properly made.

Have the joint as tight as possible, to prevent the solder from running through without filling. Apply the flux paste before any heating is done, and do not put the solder on until the work is about a low red heat, depending on the character of the work, metal, shape, etc. Apply the heat to the joint rather than to the solder, and if the solder runs immediately as it is used, have no fears as to the success of the job. In cases where a joint cannot be drawn tight, fill up with wire, scrap metal, fillings, etc., of the same metal as the work. This may also be applied to the outside of the joint if it is desired to retain solder for reinforcement.

If these rules are adhered to, it will be unnecessary to mix your flux paste on slate, and slight fingering will not prevent the making of a good joint. However, cleanliness is a trait to be cultivated, and is desirable in all soldering operations. If the joint is not reasonably clean, solder will not flow readily, more being required to dispel or vaporize the grease or other foreign matter.

SPEED OF PULLEYS AND GEARS.

In any system of pulleys or gears the general rule holds that the product of the diameters or number of teeth of the driving wheels and the number of revolutions per minute of the first driver must equal the product of the diameters or number of teeth of the driven and the number of revolutions per minute of the last driven wheel.

The most frequent pulley calculations in the machine-shop relate to the speeds of machines and countershafts, for which we have the four following rules, based upon the above principle.

First, speed of pulley on machine given, to find speed for countershaft. Multiply the number of revolutions per minute of the machine pulley by its diameter and divide this product by the diameter of the driving pulley on the countershaft.

Second, speed of countershaft given, to find the diameter of pulley to drive machine. Multiply the number of revolutions per minute of the machine pulley by its diameter, and divide the product by the number of revolutions per minute of the countershaft.

Third, speeds of main shaft and of countershaft given, to find diameter of pulley on countershaft. Multiply diameter of main pulley and divide by number of revolutions per minute of countershaft.

Fourth, speed of countershaft given, to find diameter of pulley for line shaft. Multiply number of revolutions per minute of the countershaft by the diameter of the pulley belting with the main line, and divide the product by the number of revolutions per minute of the line shaft.

ETCHING STEEL.

For etching names, dates, designs, etc., in steel, use any of the following recipes:

No. 1.—Iodine, 2 parts; potassium iodide, 5 parts; water, 40 parts.

No. 2.—Nitric acid, 60 parts; water, 120 parts; alcohol, 200 parts; copper nitrate, 8 parts.

No. 3.—Glacial acetic acid, 4 parts; nitric acid, 1 part; alcohol, 1 part.

BORING LONG CAST-IRON TUBES.

When boring long cast-iron tubes of large diameter—say 15 inches—excellent results may be attained by using kerosene as a lubricant, and a "packed bit" of the type used for gun-boring. Holes of the smoothness of glass will be the result.

TINNING CAST IRON.

The following tinning for cast iron will turn out whiter and harder than that with tin alone: Iron, 6 parts; tin, 85 grammes; nickel, 9 grammes. Dissolve the three metals in hydrochloric acid. This alloy will adhere well to the cast iron and present a very brilliant surface.

All tanks used for pickling cast iron in vitriol should be lined with lead and the seams burned together, not soldered. When a pickling tank is lined with zinc it will last but a short time under the action of the acid. Solder is also acted upon.

A HANDY DIE AND TOOL-MAKER'S CLAMP.

In Fig. 601 are shown sketches of a very handy clamp. It may be used for many purposes other than the one indicated. In this case it does away with the making of templets in die-making after the master blank has been made. First, the exact centre of the die blank is found; then the blank is placed in its proper position on the face and clamped there as shown in the sketch. Then the outline of the blank is scribed.

The clamp may also be used to hold the steel block for the punch securely against the die face; thus facilitating the turning of the work to the light and examining the inside.

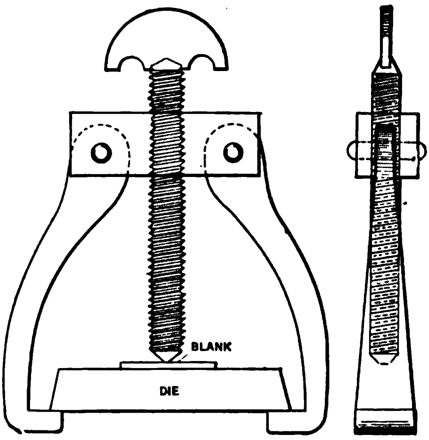


FIG. 601.

LUBRICANT FOR DRAWING SHELLS.

Take one pint of common lard oil, two pounds of opodeldoc soap, eight gallons of water; steam or heat until warm. Attach a square pan to the front of the press and keep the shells well covered. With very small shells, such as primers or pencil tips, it will be necessary to keep the solution warm; but with large shells this will not be necessary. This is the best lubricant for drawing shells from thin metal that I have ever come across.

TO GLUE LEATHER TO IRON.

To glue leather to iron, paint the iron with some kind of lead color, say white lead and lamp-black. When dry, cover with a cement made as follows: Take the best glue procurable, soak it in cold water till soft, then dissolve in vinegar with a moderate heat, then add one-third of its bulk of white pine turpentine, thoroughly mix, and by means of vinegar make it the proper consistency to be spread with a brush. Apply the cement while hot; draw the leather on or around quickly, and press tightly in place. In case of a pulley, draw the leather around tightly as possible, lay and clamp.

KEEPING NOTE-BOOKS.

Before concluding this chapter I feel that it will be well to present a few remarks on the advantage of keeping note-books in which to note and preserve the valuable and useful information which abounds in the mechanical press and which one becomes informed of through association with brother mechanics, or through experience and practical observation. It is a fact that the diffusion of knowledge is retarded greatly by mechanics in general trusting to their memory for the preservation of valuable information, instead of to more reliable means.

The most simple way to gain by one's reading and observation is to determine to fix upon some plan within one's capacity, means, and opportunity—those which come in one's daily routine—and to follow it preseveringly, regularly, and punctually, as an important factor in one's daily duties. Many men owe their success in life to the keeping of note-books in which they had noted information which, while of little moment at the time when written, proved of inestimable value at a later date.

A good way is to keep three note-books: one for jotting down items and notes and sketches which come to one in the shop through observation, hearsay, and experience. This book should be of pocket size. The second book should be a large, strongly bound manuscript book having horizontal ruled lines. In this one can write something every evening—something one has read in a mechanical paper. The third book may be a scrap-book of the usual kind, in which sketches, small drawings, diagrams, and illustrations of new machines and appliances may be pasted. By following this suggested plan one will become a close and accurate observer, an enlightened and well-informed man, and a better mechanic; no matter what line he is engaged in, he will not only gain in knowledge, but may gain financially by publishing in the mechanical press any information which has come to him through experience and observation and which appears to be new or novel.

CHAPTER XXXIII.

The Value of Up-to-date Fixtures and Machine Tools.—*Conclusion.*

In the preceding chapters I have endeavored to illustrate and describe the most approved construction and methods for accomplishing the best results in modern tool-making and interchangeable manufacturing; and before drawing this work to a close I have thought it fitting to conclude by discussing the value of improved and labor-saving fixtures and machines, and to present what to me appears to be the only system by which the American machine-shop or manufacturing plant can retain its place at the head of the world's list of industrial supremes.

LACK OF KNOWLEDGE OF MACHINE TOOLS.

Notwithstanding the vast amount of literature that is being circulated to-day describing and illustrating the uses of new machines, appliances, etc., for economic manufacturing, there is a woful lack of knowledge among shop managers, superintendents, and proprietors as to their possibilities, and among mechanics of how to operate them properly. If any one has an excuse for this lack of knowledge it is the mechanic; for while the heads of establishments are constantly receiving printed matter describing what the machine can do, and have representatives calling on them to discuss the labor-saving features of the machines they are selling, the mechanic has to rely solely upon the knowledge gained previously in the running of other similar machines to assist him in mastering the details in the operation of the new one.

"UP-TO-THE-MINUTE" MACHINE TOOLS

To-day the amount of money and time that is wasted every day in shops is apparent to very few. Even superintendents, shop managers, and master mechanics fail to realize the economy that can be effected in the production of duplicate metal articles and interchangeable machine parts and the increasing of the efficiency of the output, by replacing worn-out and obsolete machines with others that are "up-to-the-minute," equipping them with suitable fixtures and tools, and operating them as they were designed and built to be operated.

ADVANTAGES GAINED THROUGH THE USE OF IMPROVED TOOLS.

It goes without saying that the most important item in the cost of running a modern machine shop or a manufacturing plant is the labor bill. The tools and machines in the hands of and operated by the workman determine the size of the output to a given size of labor account. Thus the advantages to be gained in manufacturing by the use of up-to-date machines and special tools and fixtures are obvious; as the cost of the machines and the amount expended in the designing and constructing of special tools will be quickly balanced on the profit side when the increased output and the efficiency of the parts produced through their use are compared with the results under the old methods. Another advantage to be gained through the use of improved tools is the almost total elimination of the obtainable results depending upon the degree of skill and intelligence possessed by the workman; thus allowing of employing less expensive help in the manufacture of the required parts.

The above enumerated advantages gained through the use of modern machines and tools should be so thoroughly recognized by the executive heads of manufacturing plants that the aim should be universal to weed out all inferior tools, and allow to remain nothing but the most efficient machines, tools, and fixtures in the hands of the workman; so that the mechanic may produce a greater quantity, or a better quality of work, irrespective of his degree of skill, and without increased exertion—mentally or physically.

IDEAL TWENTIETH-CENTURY MANUFACTURING.

Ideal twentieth-century manufacturing is attained through the constant endeavor of shop officials to increase the dividend on each dollar of investment. If an old machine can be replaced with an improved one which will be capable of producing more work, or the same quantity of work with less labor, it should be installed. Often the installation of a new machine in place of an obsolete one has saved from fifteen to one hundred per cent. and over per annum on the investment. Those who doubt this assertion have only to inquire of the manufacturers of new machines in order to substantiate my claim.

DEPRECIATION IN MACHINE-SHOP.

The depreciation of a machine-shop that is merely kept in repair will pile up just as fast as better and improved machines and tools are installed and used in competing shops. The amount of depreciation will not be evidenced by the books; but it will go on just the same and dividends will be declared out of the inventory—not out of the earnings. Of course this depreciation can in some cases be continued for some years without the ultimate end coming in view. But at the best the smash will only be postponed and the result will be worse. Though this simple decline in the plant's value may not be considered of much moment, the increased cost of its product and the inferior efficiency of the same as compared with that of competing companies will eventually ruin it. While it is not always possible to replace all or even the greater part of an obsolete equipment with new machines, it can be done gradually. Keep putting in better and more efficient tools and machines every year and the plant will keep its place in the front ranks of prosperous establishments.

CAUSES OF DEPRECIATION IN SHOPS.

Lack of concentration, of specialization, of information, and too much attention to other duties in the general run of business usually account for the depreciation of a plant; as the cost of installing up-to-date fixtures for the duplicate production of small repetition parts and the replacing of old machines with improved ones will not ordinarily exceed the extra cost per year of production by old methods and of running and keeping in repair the old machines. In fact, there is *no excuse* for the non-installation in any shop of a machine which will turn out more and better work than an old one, as the manufacturers of such machines are always willing to assume all cost of demonstrating their efficiency and labor-saving qualities.

THE SELECTION OF MACHINES FOR MANUFACTURING PURPOSES.

Again, in the selection of machines for manufacturing purposes, extremes should be avoided. We have to select from the "universal type," the "special," and the "happy medium." The "universal" machine unsually lacks efficiency; and it is difficult to produce interchangeable machine parts of a high grade in it. The "special" machine lacks working range; and unless large quantities of work of the same kind are constantly required the machine is frequently idle. The "happy medium," then, is the one for most shops.

UNIVERSAL EQUIPMENT VS. WORKING-RANGE EQUIPMENT.

In the average machine-shop or manufacturing plant of today important changes frequently occur. In such establishments the efficiency of the manager lies in his ability to have the shop ready for such changes—changes which frequently entail the entire product of the works. Thus a well-informed and practical manager is able to make changes in the product and at the same time avoid an excessive depreciation of the shop's value.

The properly equipped machine-shop of to-day has an equipment which is either universal or at least within its working range and which will at the same time possess the greatest efficiency. Thus the jobbing shop will have a universal equipment; while the machine-tool shop will have a working-range equipment. It is to such plants that we owe our manufacturing supremacy, as they are the ones who compete with and undersell foreign manufacturers on their own ground.

CAUSE OF THE GREAT DEVELOPMENT IN MACHINE TOOLS.

The introducing of innovations and the adaptation of radical ideas are constantly occurring all along the lines of machine-tool manufacturing and the production of mechanical apparatus.

The cause of this wonderful growth in the number of types of machine tools, and their great capacity for fine work, may be directly traced to the great improvements in electrical devices, necessitating numbers of machine tools of improved construction to produce their complicated parts. This has been the cause of the great activity in machine-tool improvement and building because, first, it called for new methods and facilities for manufacture.

Another event having an effect on the designing and manufacturing of machinery entirely unlooked for at the time of its inception was the manufacture of the bicycle. This event brought out the capabilities of the American mechanic as nothing else had ever done. It demonstrated to the world at large that he and his kind were capable of designing and making special machinery, tools, fixtures, and devices for economic manufacturing in a manner truly marvellous; and has led to the installation of the interchangeable system of manufacture in a thousand and one shops where it was formerly thought to be impracticable.

The autocar, automobile, and autocycle are the latest creations to demand the attention of the designer, tool-maker, and the machinist. It is in the perfecting and manufacturing of these twentieth-century marvels of mechanism that they are showing the world that to them nothing is impossible, and that the ingenuity and skill which perfected the "dollar watch" will also prove adequate to produce an "automobile for the million." *Forward!*

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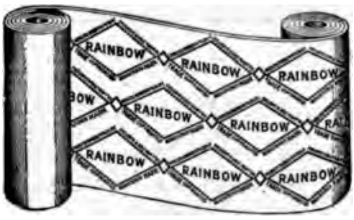

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